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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2.

VOL. CIV.—No. 2709.] *LONDON: FRIDAY, NOVEMBER 30, 1917.* [*Registered at the General Post Office as a Newspaper.*] PRICE 6d. BY IRELAND POST 10d.

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W. SHATON,
Secretary to the Education Committee.
20th November, 1917. J 521

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Wanted, for a Large Marine Engineering establishment, HEAD CLERK. Must be thoroughly experienced, also capable correspondent. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4040 and ENGINEERING. J 408

Wanted, Immediately, Prime Cost and Estimating CLERK, thoroughly experienced in General Engineering work; reliable and quick. No one employed on Government work will be engaged.—State full particulars of experience, age, whether ineligible and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 615.

Experienced Cost Clerk REQUIRED by engineers, S.E. London. Knowledge foundry costs and practical works experience preferred. No applicants residing outside radius of ten miles, or already employed on Government work can be engaged.—Write, stating age, experience and salary required, to J 542, Offices of ENGINEERING.

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College-trained Men Wanted, for reinforced concrete design and construction on important Government work. Previous experience not essential. Good opportunities for right men. No one at present on Government work or residing more than ten miles distant should apply.—Reply, stating age, qualifications, &c., to BOX 3508, care of Brown's, 39, Tothill Street, Westminster. J 581

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Draughtsmen Required, for Aeronautical work, preferably with experience of Aeroplane construction. No one on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required, and mentioning No. A 3867. J 417

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Wanted, a Draughtsman with experience of foundation and steel work design. No one employed on Government work need apply.—Apply, stating age, full particulars of experience and wage required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4100. J 586

Wanted, Draughtsman, with transformer experience. Nobody engaged on Government work will be accepted.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 4086 and ENGINEERING. J 632

Aeronautical Engineers, London, N.W., have VACANCIES for DRAUGHTSMEN preferably, but not necessarily with previous experience of aircraft work. Apply by letter, stating age, salary, particulars of experience and when disengaged. No one need apply who is engaged on Government work or who resides more than ten miles away.—BOX B 514, Sells, Ltd., Fleet Street, E.C. 4. H 965

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LONG COLUMNS CARRYING DISTRIBUTED LOADS.

By Arthur Morley.

Euler's well-known rules for finding the critical collapsing load for an ideal axially loaded column deal only with the cases in which the axial load is applied wholly at the ends, so that the thrust is the same throughout the length of the column. But in practice the load is often applied wholly or in part, continuously, or discontinuously at intervals, along the length of the column, so that the thrust increases toward one end of the column.

The compression member of a built-up structure subject to bending moment, or a long vertical column of appreciable weight* are cases in point. No doubt in a large and important structure the designer would hesitate to take any account of the fact that a strut of uniform cross-sectional area was only subjected to its maximum axial load at one end and not throughout its length, but there is an increasing demand for a class of light steel structures, carrying overhead wires for various purposes, in which minimum weight is an important consideration because of the large number to be made to an identical design, while failure due to some unprecedented condition of weather is not disastrous. In designing such a structure on a competitive basis it may be well worth while taking into account the favourable conditions enjoyed by a strut in which the axial load is distributed along the length.

In a recent paper on "The Mathematical Investigation on the Mechanical Problems of Transmission Lines,"† Mr. Koga Kato deals with the cases of struts carrying concentrated end loads, and, in addition, loads distributed uniformly along the length, and considers various types of end conditions.

It is proposed in the present article to indicate Mr. Kato's method of solution and to quote his extensive results. Also to briefly explain a method which the writer has used for cases in which the distributed axial load is not necessarily uniformly distributed along the length of the strut.

Case I.—Column on frictionless hinges at both ends and otherwise free to take any angular position as shown in Fig. 1. Let l be its length, P the concentrated top load, w the uniformly distributed (axial) load per unit of length. Let $w\,l = \mathrm{W}$ and let the load $\mathrm{P} = \gamma\,\mathrm{W}$, E = Young's modulus of elasticity for the material of the strut, I = the least modulus of inertia of the section, and let $\alpha\,l$ be the length of column from the upper end A to the point B of maximum deflection, and let the length from B to the lower end C be $\beta\,l$, so that $\alpha + \beta = 1$.

Taking A as origin and measuring x positive downwards along AC, but neglecting any lateral reaction at A, the shearing force F at any point (x, y) is then

$$-(\mathrm{P} + w\,x)\frac{d\,y}{d\,x} = d\,\mathrm{M}/d\,x = d/d\,x\left(\mathrm{E\,I}\,\frac{d^2\,y}{d\,x^2}\right) = \mathrm{E\,I}\,\frac{d^3\,y}{d\,x^3}.$$

hence

$$\frac{d^3\,y}{d\,x^3} + \frac{\mathrm{P} + w\,x}{\mathrm{E\,I}}\cdot\frac{d\,y}{d\,x} = 0$$

or

$$\frac{d^3\,y}{d\,x^3} + \frac{w\,(\gamma\,l + x)}{\mathrm{E\,I}}\cdot\frac{d\,y}{d\,x} = 0 \quad . \quad . \quad (1)$$

If $x = \alpha\,l\,v$ and $\dfrac{w\,l^3}{\mathrm{E\,I}} = \mathrm{K}$

this becomes

$$\frac{d^3\,y}{d\,v^3} + \mathrm{K}\,\alpha^2\,(\gamma + \alpha\,v)\frac{d\,y}{d\,v} = 0 \quad . \quad . \quad (2)$$

Solving this equation by a power series

$$y = \mathrm{A}_0 + \mathrm{A}_1 v + \mathrm{A}_2 v^2 + \mathrm{A}_3 v^3 + \mathrm{A}_4 v^4 + \text{etc.} \quad . \quad (3)$$

and writing $\dfrac{d^2\,y}{d\,x^2} = 0$ for $v = 0$ at the upper end, and $\dfrac{d\,y}{d\,x} = 0$ at B, *i.e.*, at $v = 1$, Mr. Kato obtains an equation

$$1 - \frac{1}{2!}\mathrm{K}\,\alpha^2\gamma - \frac{1}{3!}\mathrm{K}\,\alpha^3 + \frac{1}{4!}\mathrm{K}^2\alpha^4\gamma^2 + \frac{4}{5!}\mathrm{K}^2\alpha^5\gamma$$
$$-\frac{1}{6!}\mathrm{K}^2\alpha^6(\mathrm{K}\gamma^3 - 4) - \frac{9}{7!}\mathrm{K}^3\alpha^7\gamma^2 + \frac{1}{8!}\mathrm{K}^3\alpha^8\gamma\,(\mathrm{K}\gamma^3 - 28)$$
$$+\frac{4}{9!}\mathrm{K}^3\alpha^9\,(4\,\mathrm{K}\,\gamma^3 - 7) + \ldots\ldots\ldots = 0 \quad . \quad . \quad (4)$$

Then a similar equation in terms of K, β and γ is obtained for the lower portion C B of the column, which with (4) and $\alpha + \beta = 1$ allow of α, β and K being determined and plotted for given values of γ. If the total load,

$$\mathrm{P} + \mathrm{W} \text{ or } (\gamma + 1)\,\mathrm{W} \text{ or } (\gamma + 1)\,\mathrm{K}\,\frac{\mathrm{E\,I}}{l^2} = \mathrm{J}\,\frac{\mathrm{E\,I}}{l^2} \quad . \quad (5)$$

The now known relations between K and γ allow of the relation between γ and J being found. The exact theoretical relations are complex, but by computing values of J and plotting the curves Mr. Kato arrives at simple approximations of the form.

$$\mathrm{J} = \frac{a}{1 + b\,\gamma^d} + c \quad . \quad . \quad . \quad (6)$$

$$\alpha = \frac{a^1}{1 + b^1\,\gamma^{d^1}} + c^1 \quad . \quad . \quad . \quad (7)$$

Where a, b, c, d, a^1, b^1, c^1 and d^1 are constants. These approximate values in this case are

$$\mathrm{J} = \frac{16.7}{1 + 3.6\,\gamma} + 9.87 \quad . \quad . \quad . \quad (8)$$

$$\alpha = \frac{0.174}{1 + 2.0\,\gamma} + 0.5 \quad . \quad . \quad . \quad (9)$$

When $\gamma = \infty$, J becomes 9.87 or π^2 and $\mathrm{P} = \dfrac{\pi^2\,\mathrm{E\,I}}{l^2}$, Euler's well-known value, and $\alpha = 0.5$. While if $\gamma = 0$, $\mathrm{W} = 26.0\,\dfrac{\mathrm{E\,I}}{l^2}$ and $\alpha = 0.674$.

Cases II to VII.—Six other cases are given in Table I, representing struts under all common types of end conditions. The curves on which the approximate values of J and α are based will be found in Mr. Kato's paper previously quoted.

In cases II and III Mr. Kato has simplified the working by supposing that reactions at the ends in a direction perpendicular to the strut are avoided by such a relative lateral movement of the ends as will obviate the necessity for any lateral reaction. This is convenient mathematically, but such a favourable condition is unlikely to hold good in any actual structure, and the supposition leads to values of J which are considerably on the upper or unsafe side when γ is small.

Moreover, although Mr. Kato does not appear to have noticed it, such reactions are statically required in Cases I and IV, and their neglect leads to values of J which are too high. The writer proposes to submit modified values for the more likely conditions.

Alternative Method for any Type of Loading.—The cases given above all relate to uniformly distributed axial loading. But very frequently the increments of axial loading will not be uniform.

For example, in a cantilever consisting of tension chord and compression chord of uniform sectional areas, connected by close bracing or by a thin web of constant depth, the rate of increment of thrust (shearing force ÷ depth) on the compression chord will be nearly uniform if the whole of the bending force is applied at the free end. But if other bending loads are carried, or if the depth of the cantilever is varied to suit the variable bending moment upon it, the increments of thrust in the compression member will not be uniform.

The generalised form of equation (1) would then be

$$\mathrm{E\,I}\,.\,d^3\,y/d\,x^3 + (\mathrm{P} + \int_0^x w\,.\,d\,x)\,d\,y/d\,x = \mathrm{C}_1 \quad . \quad (1a)$$

where w may be a function of x and C is any lateral reaction at $x = 0$. For even simple functions this equation is troublesome, and a solution by series would involve much labour.

In such cases the writer has used a method similar to that previously described in an article on "Ideal Long Columns."* If the form of assumed deflection curve be carefully chosen, more than a second approximation curve will not generally be required, for the second will be as good as the application of the theory to practical cases will warrant.

Example I.—The method may well first be illustrated by the case of an axial load $\mathrm{W} = w\,l$ added at a uniform rate w per unit length of strut, in addition to an end load $\mathrm{P} = \gamma\,\mathrm{W}$. The simplest case to consider will be the column fixed at one end and entirely free at the other, *i.e.*, Mr. Kato's Case V, Table I. With the notation in Fig. 2

TABLE I.—From Mr. Kato's Paper, in which Lateral Reactions at the Ends are Neglected and $w = \dfrac{\mathrm{W}}{l}$ = Constant.

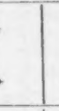
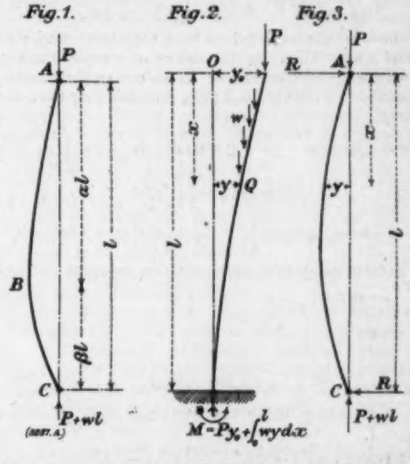
Cases	I.	II.	III.	IV.	V.	VI.	VII.
Illustrations of end conditions							
Angular changes at ends: upper	Free	Free	Not free	Not free	Free	Not free	Not free
Angular changes at ends: lower	Free	Not free	Free	Not free	Not free	Free	Not free
Lateral removal	Not free	Not free	Not free	Not free	Free	Free	Free
$\mathrm{J} = \dfrac{a}{1+b\,\gamma^d} + c$	$\dfrac{16.7}{1+3.6\gamma} + 9.87$	$\dfrac{40.6}{1+2.6\gamma^{1.35}} + 19.74$	$\dfrac{24.5}{1+1.68\gamma^{1.35}} + 19.74$	$\dfrac{46.1}{1+2.4\gamma} + 39.48$	$\dfrac{5.38}{1+2.7\gamma} + 2.47$	$\dfrac{1}{1+1.43\gamma} + 2.47$	$\dfrac{9.06}{1+1.78\gamma} + 9.87$
$\alpha = \dfrac{a'}{1+b'\,\gamma^{d'}} + c'$	$\dfrac{0.174}{1+2.0\gamma} + 0.5$	$\dfrac{0.154}{1+4.3\gamma^{1.18}} + 0.353$	$\dfrac{0.107}{1+8.8\gamma^{1.52}} + 0.647$	$\dfrac{0.105}{1+1.53\gamma} + 0.5$	—	—	—
$\mathrm{J}_{\gamma=0}$	26.6	60.3	44.25	85.6	7.85	3.47	18.93
$\mathrm{J}_{\gamma=\infty}$	π^2 9.87	$2\pi^2$ 19.74	$2\pi^2$ 19.74	$4\pi^2$ 39.48	$\frac{1}{4}\pi^2$ 2.47	$\frac{1}{4}\pi^2$ 2.47	π^2 9.87
$\alpha_{\gamma=0}$	0.674	0.507	0.754	0.605	—	—	—
$\alpha_{\gamma=\infty}$	0.500	0.357	0.647	0.500	—	—	—
$\dfrac{\mathrm{J}_{\gamma=0}}{\mathrm{J}_{\gamma=\infty}}$	2.6	3.06	2.24	2.17	3.18	1.41	1.92

Fig. 1. Fig. 2. Fig. 3.



* Euler, Heim and, later, Greenhill have investigated this particular case. See Todhunter and Pearson's "History of the Theory of Elasticity," Articles 85 and 910; Love's "Theory of Elasticity," page 405; and Cambridge Philosophical Proceedings, 1886, page 67.

† The Journal of the Society of Mechanical Engineers, Tokyo, Japan, vol. xix, November, 1915.

* See Engineering, April 24, 1914, page 566.

the bending moment at Q is then made up of that due to P, which is

$$P(y_0 - y) \quad . \quad . \quad . \quad (10)$$

and that due to the increments $w \cdot dx$ between A and Q, which is

$$w\int_0^x (y - y_0)\,dx = w\int_0^x y \cdot dx - w \cdot y\int_0^x dx = w\int_0^x y \cdot dx - w \cdot x \cdot y \quad (11)$$

The equation of bending is therefore

$$EI \cdot d^2y/dx^2 + w\left(xy - \int_0^x y \cdot dx\right) - P(y_0 - y) = 0 \quad (1B)$$

which may also easily be obtained by integrating equation (1A) when w is constant and $C_1 = 0$ and $\frac{d^2y}{dx^2} = 0$ for $x = 0$.

Now assume the deflection curve of the strut to be of the form

$$y = A + B\frac{x}{l} + C\left(\frac{x}{l}\right)^2 + D\left(\frac{x}{l}\right)^3,$$

with the constants A, B, C and D adjusted to suit the end conditions, which becomes

$$y = y_0\left\{\frac{1}{2}\left(\frac{x}{l}\right)^3 - \frac{3}{2}\frac{x}{l} + 1\right\}$$

or

$$y_0 - y = y\left\{-\frac{1}{2}\left(\frac{x}{l}\right)^3 + \frac{3}{2}\frac{x}{l}\right\} \quad . \quad (12)$$

which is the form taken by a cantilever under an end load. Then by the theory of simple bending, equating the moment of resistance to the bending moment, from (1B) and (12), remembering that any term

x^n in y becomes $n/(n+1)$ times x^{n+1} in $\left(xy - \int_0^x y \cdot dx\right)$,

$$EI\frac{d^2y}{dx^2} = Py_0\left\{-\frac{1}{2}\left(\frac{x}{l}\right)^3 + \frac{3}{2}\frac{x}{l}\right\} +$$

$$wy_0 l\left\{-\frac{3}{8}\left(\frac{x}{l}\right)^4 + \frac{3}{4}\left(\frac{x}{l}\right)^2\right\} \quad . \quad . \quad . \quad (13)$$

Integrating and adjusting the constant so that $\frac{dy}{dx} = 0$ for $x = l$,

$$EI\frac{dy}{dx} = Py_0 l\left\{-\frac{1}{8}\left(\frac{x}{l}\right)^4 + \frac{3}{4}\left(\frac{x}{l}\right)^2 - \frac{5}{8}\right\} +$$

$$wy_0 l^2\left\{-\frac{3}{40}\left(\frac{x}{l}\right)^5 + \frac{1}{4}\left(\frac{x}{l}\right)^3 - \frac{7}{40}\right\} \quad . \quad . \quad (14)$$

Integrating under the condition that $y = 0$ for $x = l$,

$$EI \cdot y = P \cdot y_0 l^2\left\{-\frac{1}{40}\left(\frac{x}{l}\right)^5 + \frac{1}{4}\left(\frac{x}{l}\right)^3 - \frac{5}{8}\cdot\frac{x}{l} + \frac{2}{5}\right\} +$$

$$wy_0 l^3\left\{-\frac{1}{80}\left(\frac{x}{l}\right)^6 + \frac{1}{10}\left(\frac{x}{l}\right)^4 - \frac{7}{40}\frac{x}{l} + \frac{1}{8}\right\} \quad . \quad (15)$$

At $x = 0$, putting $P = \gamma W = \gamma wl$,

$$y_0 = \frac{Wl^2 y_0}{EI}\left(\frac{1}{8} + \frac{2}{5}\gamma\right) = \frac{Wl^2 y_0}{EI}\cdot\frac{5 + 16\gamma}{40} \quad . \quad (16)$$

hence,

$$W = \frac{40}{5 + 16\gamma}\cdot\frac{EI}{l^2} = \frac{8}{1 + 3.2\gamma}\cdot\frac{EI}{l^2} \quad . \quad (17)$$

$$W + P = (1 + \gamma)W = \left(2.5 + \frac{5.5}{1 + 3.2\gamma}\right)\frac{EI}{l^2} = J\frac{EI}{l^2} \quad (18)$$

Equation (18) gives approximately the value of J shown in Table I, Case V, and for $\gamma = \infty$ it gives the well-known approximation $J_\infty = 2.5$ (instead of 2.47 or $\pi^2/4$), and for $\gamma = 0$ the approximation $J_0 = 8$.

A second calculation will give a rather nearer approximation. To obtain this it will be simpler to omit P and find the value for $P = 0$, *i.e.*, $\gamma = 0$.

Dividing equation (15) by equation (16), when $\gamma = 0$

$$y = y_0\left\{-\frac{1}{10}\left(\frac{x}{l}\right)^5 + \frac{1}{2}\left(\frac{x}{l}\right)^4 - \frac{7}{5}\frac{x}{l} + 1\right\} \quad . \quad (19)$$

Substituting this value of y in (11) and equating to the moment of resistance

$$EI\frac{d^2y}{dx^2} = wy_0 l\left\{\frac{3}{35}\left(\frac{x}{l}\right)^7 - \frac{2}{5}\left(\frac{x}{l}\right)^5 + \frac{7}{10}\left(\frac{x}{l}\right)^2\right\} \quad . \quad (20)$$

Integrating under the condition $dy/dx = 0$ at $x = l$

$$EI\frac{dy}{dx} = wy_0 l^2\left\{\frac{3}{280}\left(\frac{x}{l}\right)^8 - \frac{1}{15}\left(\frac{x}{l}\right)^6 + \frac{7}{30}\left(\frac{x}{l}\right)^5 - \frac{149}{840}\right\} \quad (21)$$

And integrating again so that $y = 0$, for $x = l$

$$EI \cdot y = wy_0 l^3\left\{\frac{1}{840}\left(\frac{x}{l}\right)^9 - \frac{1}{105}\left(\frac{x}{l}\right)^7 + \frac{7}{120}\left(\frac{x}{l}\right)^4 - \frac{149}{840}\frac{x}{l} + \frac{107}{840}\right\} \quad . \quad . \quad . \quad (22)$$

and at $x = 0$

$$EI \cdot y_0 = wy_0 l^3 + \frac{104}{840} \text{ or } \frac{107}{840}Wl^3 y_0.$$

hence

$$W = \frac{840}{107}\frac{EI}{l^3} = 7.85\frac{EI}{l^3} \quad . \quad . \quad (23)^*$$

Similarly if W had been taken as zero (*i.e.*, $\gamma = \infty$), the well-known value

$$P = 2.47\frac{EI}{l^2}\left(\text{or } \frac{\pi^2}{4}\frac{EI}{l^2}\right)$$

would have been found. Combining these results, for any value of γ, approximately

$$W = \frac{EI}{l^3} \div \left(\frac{1}{7.85} + \frac{\gamma}{2.47}\right) = \frac{7.85}{1 + 3.18\gamma}\frac{EI}{l^3} \quad (24)$$

$$W + P = (1 + \gamma)W = \left\{2.47 + \frac{5.37}{1 + 3.18\gamma}\right\}\frac{EI}{l^2} = J\cdot\frac{EI}{l^2} \quad . \quad . \quad . \quad (25)$$

This agrees fairly well with Mr. Kato's value of J in Case V, and gives the same values of J for $\gamma = 0$ and for $\gamma = \infty$.

Fig. 4.

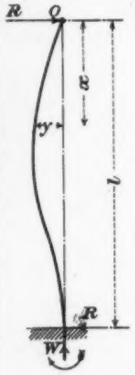


Fig. 5.

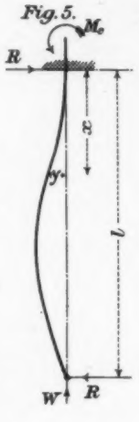


Fig. 6.

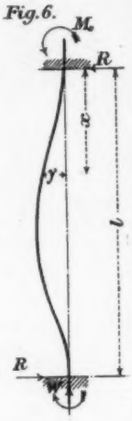


Fig. 7.

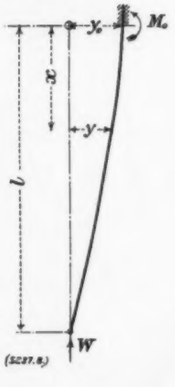


Fig. 8.

Example II.—Again taking $w = \frac{W}{l}$ and $P = 0$ the strut hinged at both ends (Case I, Table I) will have lateral end reactions R as shown in Fig. 3 if the hinged ends remain in the straight line originally joining them. Using the notation of Fig. 3, with A as origin, the general equation

$$y = A + B\frac{x}{l} + C\left(\frac{x}{l}\right)^2 + D\left(\frac{x}{l}\right)^3 + E\left(\frac{x}{l}\right)^4 \quad (26)$$

combined with the four end conditions $y = 0$ for $x = 0$ and $x = l$ and $\frac{d^2y}{dx^2} = 0$ for $x = 0$ and $x = l$ gives

$$y = \frac{16}{5}y'\left\{\left(\frac{x}{l}\right)^4 - 2\left(\frac{x}{l}\right)^3 + \frac{x}{l}\right\} \quad . \quad (27)$$

as a first form of y, where y' is the deflection y, at $x = \frac{l}{2}$.

Inserting this in equation (1A), where $C_1 = -R$, and integrating with added constant zero, since the bending moment is zero at $x = 0$,

$$EI\frac{d^2y}{dx^2} = -w\left\{xy - \int_0^x y\,dx\right\} - Rx = -\left\{\frac{16}{5}Wy\left\{\frac{4}{5}\left(\frac{x}{l}\right)^5 - \frac{3}{2}\left(\frac{x}{l}\right)^4 + \frac{1}{2}\left(\frac{x}{l}\right)^2\right\} - Rx\right\} \quad (28)$$

and since this is zero for $x = l$,

$$R = \frac{16}{25}W\frac{y'}{l} \text{ and}$$

$$EI\frac{d^2y}{dx^2} = -\frac{16}{5}Wy'\left\{\frac{4}{5}\left(\frac{x}{l}\right)^5 - \frac{3}{2}\left(\frac{x}{l}\right)^4 + \frac{1}{2}\left(\frac{x}{l}\right)^2 + \frac{1}{5}\frac{x}{l}\right\} \quad (29)$$

Integrating this twice, under the conditions that $y = 0$ for $x = 0$ and $x = l$,

$$EI\frac{dy}{dx} = -\frac{16}{5}Wy'l^2\left\{\frac{2}{15}\left(\frac{x}{l}\right)^6 - \frac{3}{10}\left(\frac{x}{l}\right)^5 + \frac{1}{6}\left(\frac{x}{l}\right)^3 + \frac{1}{10}\left(\frac{x}{l}\right)^2 + A\right\} \quad (30)$$

$$EI \cdot y = -\frac{16}{5}Wy'l^3\left\{\frac{2}{105}\left(\frac{x}{l}\right)^7 - \frac{1}{20}\left(\frac{x}{l}\right)^6 + \frac{1}{24}\left(\frac{x}{l}\right)^4 + \frac{1}{30}\left(\frac{x}{l}\right)^3 - \frac{37}{840}\frac{x}{l}\right\} \quad (31)$$

and when $x = \frac{l}{2}$

$$EI \cdot y' = \frac{61}{1200}Wy'l^2 \quad . \quad . \quad . \quad (32)$$

whence, as a first approximation,

$$W = \frac{1200}{61}\frac{EI}{l^2} = 19.7\frac{EI}{l^2} \text{ or } J_{\gamma=0} = 19.7 \quad . \quad (33)$$

Taking a second approximation, from (32) and (33),

$$y = -\frac{3840}{61}y'\left\{\frac{2}{105}\left(\frac{x}{l}\right)^7 - \frac{1}{20}\left(\frac{x}{l}\right)^6 + \frac{1}{24}\left(\frac{x}{l}\right)^4 + \frac{1}{30}\left(\frac{x}{l}\right)^3 - \frac{37}{840}\frac{x}{l}\right\} \quad (34)$$

And treating this in the same way as (27) the second approximation is

$$W = 18.796\frac{EI}{l^2} \quad . \quad . \quad . \quad (35)$$

From which about $18.7\frac{EI}{l^2}$ may be judged to be the approximate limiting value of W, or $J_{\gamma=0} = 18.7$ instead of 26.6, the value given by equation (8), where R is neglected.

Loads not Uniformly Distributed.—Considering now the more general cases in which the distributed axial load is not added at a uniform rate, unless the loading follows exactly some simple law it will be convenient to plot, on the length of the column as a base line, the total axial load at each section. It will then be usually found easy to envelop such a curve of loading by a curve following a simple law, and giving the same maximum load at the heavily loaded end of the column.

As an alternative any loading, however irregular, may be dealt with by dividing the column length into a number of equal parts and performing the integration by tabulation in a manner very similar to that exemplified in the writer's article on "Critical Loads for Long Tapering Struts."*

Example III.—Repeating Example II, but taking a load W distributed so that $w = \frac{2Wx}{l^2}$ or $\int_0^x w\,dx = W\frac{x^2}{l^2}$ each term $\left(\frac{x}{l}\right)^n y'$ in the assumed value of y, equation (27) will give a term $wy'\frac{n}{n+2}$ in the integrated form of equation (1A) which, with $P = 0$, is

$$EI\frac{d^2y}{dx^2} + W\left\{y\frac{x^2}{l^2} - \frac{2}{l^2}\int_0^x yx\,dx\right\} = C_1 x + M_0 \quad . \quad (36)$$

This then, M_0 being zero, becomes

$$EI\frac{d^2y}{dx^2} = -\frac{16}{5}Wy'\left\{\frac{2}{3}\left(\frac{x}{l}\right)^6 - \frac{6}{5}\left(\frac{x}{l}\right)^5 + \frac{1}{3}\left(\frac{x}{l}\right)^3 + \frac{1}{5}\frac{x}{l}\right\}$$

and proceeding as in Example II a first approximation is

$$W = 25.71\frac{EI}{l^2} \quad . \quad . \quad . \quad (37)$$

and the second approximation is

$$W = 23.77\frac{EI}{l^2} \text{ or } J_{\gamma=0} = 23.77 \quad . \quad . \quad (38)$$

Combinations of Concentrated and Distributed Loads.—When P is not zero and w is some assigned

* Heim, *loc. cit.*, gives the factor 7.83725, and Greenhill 7.9524 for this case.

* See ENGINEERING, September 21, 1917, page 295.

function of x and W, for all cases of end conditions of the strut, the present method will yield an equation of the type (16), the two portions of the right-hand side of equations of the type (13) being independent. Hence an equation of the type (18) may always be obtained. Its general form is

$$\left.\begin{aligned} W + P = \frac{E\,I}{l^2} &= \frac{\gamma+1}{\frac{1}{J_{\gamma=0}} + \frac{\gamma}{J_{\gamma=\infty}}} \cdot \frac{E\,I}{l^2} \\ \text{or } J &= \frac{\gamma+1}{\frac{1}{J_{\gamma=0}} + \frac{\gamma}{J_{\gamma=\infty}}} \end{aligned}\right\} \quad (39)$$

This, therefore, is a good approximation for J for all values of γ and as the values of $J\,\gamma = \infty$ are all well known, it is only necessary to find $J_{\gamma=0}$ and then the general value of J may, if desired, be calculated easily from equation (39).

Other Types of Loading.—If

$$w = \frac{2\,W}{l}\left(1 - \frac{x}{l}\right) \text{ or } \int_0^x w\,dx = 2\,W\frac{x}{l} - W\frac{x^2}{l^2}$$

(which does not differ greatly from

$$w = \frac{W}{l}\frac{\pi}{2}\cos\frac{\pi}{2}\frac{x}{l} \text{ or } \int_0^x w\,dx = W\sin\frac{x}{l}\frac{\pi}{2}\Big)$$

the method of Examples II and III may be used, but it will be noticed that the portions of the equations arising from the two parts of w may be treated independently and the term $\frac{2\,W}{l}$ is just twice the rate of loading in Example II, while the term $-2\,W\frac{x}{l^2}$ is the rate of loading in Example III with the sign reversed. Hence from the manner of arriving at the value of W it is evident that, *e.g.*, for the strut hinged at both ends the result may be derived from those already estimated, for, taking the results of Examples II and III,

$$W = \frac{E\,I}{l^2} \div \left(\frac{2}{18.80} - \frac{1}{23.77}\right) = 15.5\,\frac{E\,I}{l^2} \quad . \quad (40)$$

From which it may be taken that $J_{\gamma=0}$ is in this case about 15. Where w takes other forms, *e.g.*,

$$w = \frac{W}{2\,l}\sqrt{\frac{l}{x}}, \int_0^x w\,dx = W\sqrt{\frac{x}{l}},$$

the method described may be used, but the values of w already illustrated are perhaps, with possible combinations, the most useful types, and may be made to cover any type of distributed axial loading likely to arise.

Other End Conditions.—The method of obtaining the values of $J_{\gamma=0}$ has been sufficiently illustrated, and it is not necessary to set forth in detail the calculations for all the end conditions given in Table I, but the writer has made them to a second approximation, and the results are given in Table II, the values of $J_{\gamma=0}$ stated being a little below those found by a second approximation.

The following are the primary forms of y, where y_0 is the value of y at $x = 0$ and y' is the value of y at $x = \frac{1}{2}\,l$.

Case I, Fig. 3—

$$y = \frac{16}{5}y'\left\{\left(\frac{x}{l}\right)^4 - 2\left(\frac{x}{l}\right)^3 + \frac{x}{l}\right\}.$$

Case II, Fig. 4—

$$y = 4\,y'\left\{2\left(\frac{x}{l}\right)^4 - 3\left(\frac{x}{l}\right)^3 + \frac{x}{l}\right\}$$

Case III, Fig. 5—

$$y = 4\,y'\left\{2\left(\frac{x}{l}\right)^4 - 5\left(\frac{x}{l}\right)^3 + 3\left(\frac{x}{l}\right)^2\right\}$$

Case IV, Fig. 6—

$$y = 16\,y'\left\{\left(\frac{x}{l}\right)^4 - 2\left(\frac{x}{l}\right)^3 + \left(\frac{x}{l}\right)^2\right\}$$

Case V, Fig. 2—

$$y = y_0\left\{\frac{1}{2}\left(\frac{x}{l}\right)^3 - \frac{3}{2}\frac{x}{l} + 1\right\}$$

Case VI, Fig. 7—

$$y = y_0\left\{\frac{1}{2}\left(\frac{x}{l}\right)^3 - \frac{3}{2}\left(\frac{x}{l}\right)^2 + 1\right\}$$

Case VII, Fig. 8—

$$y = y_0\left\{2\left(\frac{x}{l}\right)^3 - 3\left(\frac{x}{l}\right)^2 + 1\right\}$$

TABLE II.

Load per unit length = w.	$\frac{W}{l}$	$W\frac{2x}{l^2}$	$\frac{2W}{l} - \frac{2Wx}{l^2}$
Total load at x from origin = $\int_0^x w\,dx$ ..	$W\frac{x}{l}$	$W\frac{x^2}{l^2}$	$W\left(2\frac{x}{l} - \frac{x^2}{l^2}\right)$
Approximate values of—			
$J_{\gamma=0}$, Case I, Fig. 3 ..	18.7	23.7	15.4
$J_{\gamma=0}$, Case II, Fig. 4 ..	49	80	35
$J_{\gamma=0}$, Case III, Fig. 5 ..	29	38	24
$J_{\gamma=0}$, Case IV, Fig. 6 ..	76	110	57
$J_{\gamma=0}$, Case V, Fig. 2 ..	7.8	16	5
$J_{\gamma=0}$, Case VI, Fig. 7 ..	3.45	4.50	2.83
$J_{\gamma=0}$, Case VII, Fig. 8..	18.9	31.0	13.5

Conclusion.—There is nothing in the method described and illustrated that is not applicable to struts or columns of varying section. It is only necessary if I varies with x to write $d/dx(E\,I\,d^2y/dx^2)$ in place of $E\,I\,d^3y/dx^3$ in equation (1A), and then in subsequent integrations to treat I as a variable, as in the writer's article previously quoted, but generally the algebraic work will be complicated, and integration by tabulation or by measurement of areas may be necessary.

In conclusion it may be recalled that actual columns and struts are designed, generally by empirical rules, for conditions differing somewhat widely from the ideal conditions of truly axial loading, initial straightness of axis, homogeneity, &c. Like Euler's well-known values for the critical concentrated loads under ideal conditions, the values here calculated supply only the bases of working formulæ or a comparison of resistances under different conditions of loading and support.

TUNGSTEN AND HIGH-SPEED STEEL.

In our issue of October 26, page 432 *ante*, the processes were described by which pure tungsten is obtained from wolframite in the Widnes works of the High-Speed Steel Alloys, Limited. The purpose of the present article is to describe the processes of making high-speed steel by alloying the tungsten with iron. The former metal is used to the extent of 18 per cent. to 20 per cent., and the essential and remarkable qualities of the alloy are mainly due to its use.

Tungsten powder is, of course, also produced abroad, but British requirements are now supplied from Widnes. No other alloy equals the high-speed steels and vanadium high-speed steels manufactured by makers of repute in Sheffield and Manchester; they are undoubtedly superior for all purposes where heavy and continuous work is required. The processes we describe are essentially those employed by the companies obtaining their supplies of tungsten from the Widnes works; in the aggregate these firms form a very important portion of industrial Sheffield, both as regards output, capital and as employers of labour. These companies have not only maintained a world-renowned reputation for the production of tool steel, they have also given a lead to the engineers of the world by the splendid results obtained by means of their high-speed steels, and more especially by the more recent introduction of tungsten-chrome-vanadium high-speed steel. The consumption of tool steel is very great at the present time; the companies referred to above had a combined output of high-speed steel prior to the war of from 70 per cent. to 80 per cent. of the total output of the country.

High-speed steel obtained its name on account of its qualities and characteristics, which may be summarised as follows: the great increase in the surface depth of cut and speed which can be obtained; and the high speed with which work can be turned out of the shops. The increase in output, however, is not only due to depth of cut and surface speed, but mainly to the quality of retaining a cutting edge or face sufficiently hard to resist the wear and pressure of the chip being removed from the stock, even when the tool nose becomes red hot, which gives high-speed steel its great advantage over carbon steel. It may be interesting at this point to give a brief résumé of the various processes of manufacture, which are as follow:—

1. By the well known melting hole or furnace, in which the material is melted in fireclay or plumbago crucibles, the heat being obtained from coke by natural draught.

2. The same method as the first, but with producer gas in place of coke.

3. By means of the Siemens furnace.

4. By the same process as the first, but with the addition of forced draught in place of the natural draught.

5. By melting in one of the varieties of the electric furnace.

The first method of melting steel was introduced into Sheffield as far back as 1740 by Huntsman; it is by his method that the town has built up its reputation for tool steel, which it enjoys at the present time. Methods 2, 3, 4 and 5 have advantages, and several makers claim special virtues for their particular output, nevertheless the crucible process (methods 1 and 2 above), in spite of its considerable antiquity, continues to maintain its superiority over the other processes; it is therefore the method of manufacture preferred, practically without exception, by all companies of repute. The plant required for the first process is as follows:—

(*a*) The melting furnaces, which consist of a series of small chambers called "holes," built below the floor-level of the furnace room, the top being closed by a firebrick cover, whilst the bottom is built around a cast-iron frame, which supports a series of fire or grate bars. There is a flue from the top of each "hole" connected with the chimney stack, by means of which the draught necessary for the melting is obtained. These furnaces are each large enough to accommodate two crucibles or pots and the necessary fuel (*i.e.*, coke) for melting.

(*b*) The crucible or pot and its lid.

(*c*) An annealing grate in which the fireclay crucibles are preheated or annealed before being placed in the melting furnace.

(*d*) High-grade coke with a sulphur content as low as commercially possible.

(*e*) Cast-iron moulds of various shapes into which the metal is poured when melted to form ingots.

(*f*) "Dozzles" or fireclay "feeders," which are put on the top of the ingot immediately it is cast, to reduce the amount of "pipe," or, in other words, the unsound and therefore unusable portion of the ingot, to a minimum.

The essential materials, apart from tungsten, required for the production of high-speed steel vary to some extent in the different works engaged in the manufacture of this class of steel. In most houses of repute the basis is the exceptionally pure form of iron imported from Sweden and sent to this country in the form of iron bars, hammered or rolled, according to the quality of the steel to be made. If the iron has been previously "cemented" it is easily broken to the required size.

The standard section is 3 in. by $\frac{3}{4}$ in., the lengths varying as may be found convenient. The first step in the process is to cut up these bars into small pieces, square or triangular, of, say, 2 sq. in. or 3 sq. in. of area each; these, coming straight from the store, may be more or less covered with rust, except on the cut surfaces; most of the firms use them in this state, but some remove the rust so as to render the final product as free from the oxide as possible. This is effected by throwing the material into a rapidly revolving "rumble," in which the rust, or oxide, is effectually removed, but this process is not absolutely essential. In addition to the Swedish iron a proportion of suitable scrap is also used; a considerable supply obtained from various sources is available; its use reduces the consumption of imported Swedish iron and constitutes an important and desirable economy.

The second step in the process of making high-speed steel is a very important one. According to the class of steel required the ingredients have to be mixed with the greatest care and accuracy in accordance with detailed specifications, in which the weights and quantities have been worked out. The department in which this operation takes place is known as the "weigh-up house," and in some of the works as the "medicine house." The materials as weighed are put into a flat, open pan, a separate weigh pan being reserved for each pot or crucible. The materials mixed and weighed are the Swedish

iron, scrap, tungsten, chromium and, when necessary, vanadium, molybdenum, manganese, silicon and carbon. Some manufacturers substitute other alloys for one or more of the foregoing, but they need not be further referred to in this article, which is limited to Sheffield's best quality of high-speed steel. The weigh-pans, with their carefully sorted and weighed contents, are transferred to the adjoining melting-house, where the crucibles are being raised to such a temperature as to make it safe to transfer the contents of the weighpans to them.

The melting-house is a building containing two ranges of furnaces, one down each side. These furnaces are, as stated above, a series of small chambers built below the floor-level, with movable covers level with the floor and vertical flues built in the thickness of the walls.

Two "pot stands"—which are generally the two halves of an ordinary firebrick "square," but in some cases are of special preparations—are placed on the grate bars of the furnaces or holes, one for each of the two crucibles in each furnace. The crucibles, which are about 18 in. in height and 9 in. in their greatest diameter, are very rapidly transferred from the crucible annealing grate and placed one upon each of the pot stands already in the furnaces. Live coals are heaped round the bottom of the crucibles, and the fire is built up with coke or coal, as the melter may consider desirable. After the lapse of possibly an hour, or an hour and a half, the temperature is such that it is safe to introduce the materials to be melted into the crucibles. The contents of a weigh pan are emptied into each crucible by means of a metal funnel or cylinder known as a "charger." about 4 ft. in length, with the opening wider at the top than at the bottom. When the charger mentioned above is in position a man with a long poker or "potter," as it is called, prevents the fall of any specially large piece from the weigh pan by breaking it, and thus avoids any possible damage to the crucible. This process is the "steeling of the pots." Steeling completed, the lids are carefully placed on the crucibles, the fires built up with coke until the crucibles are completely covered, and the melting process commences. The charge is left in the crucible for approximately 4 or 4½ hours, when the metal, then in the form of high-speed steel, but in a molten condition, is ready for "teeming." Ingots of almost any weight can be cast, from 40 lb. to 10 tons or 20 tons, where the united capacity of the furnaces will allow that to be done.

The weight melted in each pot is subject to variation in different works, but on an average is approximately 60 lb. per pot. To each of the men in a gang some special duty is allotted. There are two "pullers" for every 24 crucibles, and their duties are to pull the crucibles out of the melting holes on to floor-level. Having lifted the crucible out just clear of the top of the hole, they slowly revolve the pot whilst one of the other men chips away the slag and dirt which have adhered to the bottom of the crucible. This is done for the double reason of not only reducing the weight that the teemer has to lift, but also to make it easier to put the crucible, when empty, back into its place in the hole. When the slag has been removed the puller slides the crucible along the floor to the place where the teemer is waiting to do his share of the work.

Moulds.—Alongside is a series of cast-iron moulds, which are generally about 3 in. square in cross-section, and 30 in. in length. They are arranged so that the top is at a convenient height for the teemer, who, by means of a special pair of tongs, has to pick up the crucible and slowly pour the white-hot contents into the mould. To do this properly requires considerable knack and skill, because it is essential that the stream of molten metal shall from the first go straight to the bottom of the mould without even momentarily touching any of the four sides during the operation. When the metal has risen to within, say, 3 in. of the top of the mould, a "dozzle," which has been previously heated in one of the holes, is quickly dropped on top of the metal in the mould, and held in position whilst the few pounds of metal remaining in the crucible are poured through its centre.

Dozzle.—The dozzle is a small block formed of fireclay, just large enough to fit into the top of the mould, about 4 in. long, with a hole from 1¼ in. to 1½ in. in diameter running longitudinally through its centre. It serves to keep this last portion of the metal hot, and as the ingot cools, and also contracts, the portion in the dozzle tends to sink down or feed into the main body of the ingot and so fill what would otherwise be a cavity or pipe caused by the shrinkage of the cooling metal. The dozzle not only reduces the pipe in the top part of the ingot, which at all costs must be discarded, but also minimises the weight of metal immediately surrounding the part, which of necessity has to be scrapped.

Topping.—The process of eliminating the pipe is called "topping," and consists of breaking pieces from the top or dozzle-feed end, of the ingot till all "pipe" or unsoundness has been removed and only good, sound steel remains. This topping also serves to reveal any fracture of the ingot, and from this the experienced eye is able to judge whether or not the material has been properly treated during the melting process.

The empty crucibles are then lowered into the furnace to be reheated, and as soon as the necessary temperature has been reached they are refilled with another charge; the operations described in detail above are then in due course repeated.

Analysis.—Before the ingots are available for other processes they are kept in hand until the chemist has made a complete analysis. A typical analysis of the tungsten-chrome-vanadium variety of tool steel, which, as already stated, has a leading place amongst the competing steel alloys where continuous hard work has to be faced, is approximately as follows:—

	Per cent.
Carbon	0.65
Manganese	0.20
Silicon	0.20
Phosphorus	0.010
Sulphur...	0.075
Tungsten	18.5
Chromium	3.75
Vanadium	0.85

Having ascertained that—

1. The melting process has been properly conducted.
2. The analysis is within reasonable limits of the specification;
3. The surface of the ingot is smooth and clean;

the ingot is allowed to go to the forge.

Forging.—The ingot is first put into a furnace in which the heating is very slow and gradual from almost cold to a dull red. It is then transferred to a hotter furnace, and is kept there till thoroughly "soaked." If the ingots have been carefully and thoroughly soaked the forging of the steel presents no very serious difficulties, but should any hammer work be attempted before the heating has been done it would almost certainly result in the ingot breaking up in all directions, or at any rate cracking in such a way as to render the steel useless for the manufacture of cutting tools. The reduction in size by the hammer is at this stage very slight, and is called the "cogging process." After cogging the bars are allowed to cool, being placed in closed boxes or in hot ashes so as to avoid too rapid cooling.

Pickling.—The bars are next pickled in a bath of hot dilute sulphuric acid or some suitable substitute, such as nitre cake. The acid removes the scale or oxide that has formed during the cogging process. The bars, on being withdrawn from the acid, are carefully washed in clean water, or in some works in lime water. In this state any slight cracks or other surface defects are readily detected, and the bars are looked over before any rust begins to form. The duty of the "looker over" is to detect even the slightest hair-like crack or other defect, and near these he paints a white mark. The bars so marked are placed on special benches, where the defects are carefully ground away by means of corundum wheels. The ground bars are now ready for the finishing process.

Finishing.—Finishing is done by one of three means:—(1) The forging hammers (any hammer with a capacity of over 12 cwt.); (2) the "tilts" (small hammers of under 12 cwt. capacity); or (3) the rolling mill. The particular process to be used depends upon the required size of the finished bar, and, as a more or less general rule, larger sizes are hammered, medium sizes tilted, and small sizes rolled. In any of these methods the temperature at which the material is worked is of the greatest importance, just as in the case of cogging. When a sufficiently high temperature is maintained no serious difficulties are met, but any attempt to work at a low temperature invariably brings disaster and the bar becomes scrap.

Tilting.—In the tilting process the bars are gradually worked to the desired section and size under small power-driven (steam or pneumatic) hammers of from, say, 4 cwt. to 12 cwt. capacity. These hammers do their work by a series of very rapid blows, which may be heavy or light, as desired. When the required dimensions is attained the bar is straightened and allowed to cool, having first been protected from cold air, as in the case of the cogged bar.

Rolling.—In the alternative rolling process the bar is rolled, generally in the old fashioned "two-high" mill.

Annealing.—There are numerous types of annealing furnaces, but the general principle of each is the same. In these furnaces several bars are generally packed together in a more or less cold furnace. The temperature is gradually raised, and having reached the desired maximum the heat is maintained at this for about an hour, and the furnace and contents are allowed to cool as slowly as possible, after which the bars are again pickled.

Inspection.—Finally the bars are taken to the steel warehouse. Here they are most carefully looked over for surface defects, and a small piece is broken from both ends of each bar. Those showing the least defect are discarded or scrapped, whilst the sound ones, after being marked with the maker's name, are ready for delivery to the manufacturer of the tools for which the steel is intended.

The Manufacture of the Crucibles.—It is all-important for the successful production of high-speed steel that the crucibles should be perfect, and the greatest care is devoted to their production, as even the slightest defect might result in the loss of the metal when they are charged. These crucibles are generally made at each of the works producing high-speed steel, and a department with its special staff of trained men is set apart for the purpose. A variety of carefully selected clays are used, very finely ground, which are mixed as regards quantity and quality in accordance with the judgment of the pot-maker in charge of the department. The clay is carefully weighed out in suitable quantities, then spread on an iron floor, known as the "treading" floor, which is a large rectangular tray with sides 6 in. in height, on which it is thoroughly sieved and mixed in the dry state, and any foreign matter found is immediately removed. Water is then added, and the clay is again thoroughly mixed by means of a shovel, kneaded and compressed to force out air, also for the detection and removal of any substance such as a pin, piece of wire, or anything else which might otherwise get into the substance of the crucible. This is the so-called treading process, which has been compared to the kneading of bread, but instead of being done by the hands, as in the case of bread, it is done by the naked foot. The foot being sensitive, any objectionable or dangerous foreign matter which may have slipped through the sieve by accident can be detected and removed. The clay is then cut into blocks and weighed, each sufficient for the production of one crucible, and taken to the "balling table" to be "balled"; that is, beaten, tossed and banged by hand, and again carefully examined for air pockets or cavities. The experienced eye of the "baller" can at once detect the presence of any air pockets by the slight swelling on the surface of the clay produced as the mass is banged on the balling table. Any such swelling is opened out and the air liberated; the process is continued until the block of clay has been brought to a thoroughly homogeneous mass. The blocks, about 12 in. by 9 in. by 6 in., are then ready to be transferred to the "plug and flask," in which the plastic clay is plugged or moulded to shape by means of a ram forced vertically into a mould. The pots are then removed to a drying-

house, or in some works to a cellar, where they are kept for at least a month, during which the moisture gradually dries out. They are then transferred to the furnace-house described above and placed on shelves fixed to the walls above the furnaces or melting holes until they are required. About 21 hours before that the crucibles required for one day's work are placed in an annealing grate built at one end of the furnace-house and are placed on bars with just enough space between the crucibles to allow them to be completely packed and covered with small coke until the grate is filled to the top. Sufficient fire is then put underneath the grate bars to start the coke burning at the back and bottom of the annealing grate. The fire gradually works its way forwards and upwards, until the whole mass of coke in the annealing grate, with the included crucibles or pots, is aglow. This operation has to be carefully watched, and requires judgment and experience so as to avoid over or under-annealing, known among the men as "hot-nailing" or "slack-nailing." The crucibles, in their red-hot condition, are then ready for use, that is, to be transferred to the furnaces or melting holes and the process described above.

The crucibles are generally only used twice, very occasionally three times, but in some works they are made to produce two rounds of high-speed steel and one of carbon steel, or one round of high-speed steel, one of special carbon tool steel, and a third round of file steel, as may be required, the output of the works making high-speed steel being extremely varied.

The weight of an annealed pot as used in the high-speed steel processes detailed above is, on the average, about 30 lb., occasionally more or less; whilst the quantity of material which these crucibles or pots can contain varies from 40 lb. to 70 lb.

STANDARD PROPELLING ENGINES FOR BRITISH STANDARD SHIPS.

In supplement to our article on British Standard Ships, which we published in an earlier issue (page 553 *ante*), we now give, on page 578 and on Plate LV, accompanying this issue, illustrations of the standard engines designed and built for these ships. The main engine design does not present any new features, and is fairly representative of that usually adopted for triple-expansion engines having cylinders 27 in., 44 in. and 73 in. diameter by 48-in. stroke. The outstanding feature, which indicates that the design is of Clyde origin, is the front columns which carry the piston-rod guides, as against the slipper-type guide which is a feature of the North-East Coast design. Special attention has been given to details for convenience in machining and assembling, the piston type of valve for the medium-pressure cylinder, for example, being adopted chiefly on that account. The circulating pump, which is of the centrifugal type, 12-in. bore branches, is mounted with its engine on the main engine bedplate so as to enable it with its pipes and connections, to be fitted complete in the erecting shop. The reversing engine is of the usual all-round type, and an independent turning engine is provided.

All the designs, with the exception of the auxiliary machines, were, of course, prepared by one firm, who had extensive experience in machinery of this size for cargo vessels, and were issued to the various machinery contractors complete, together with full detail specifications of all the raw material orders and the finished items which it was arranged to obtain from sub-contractors. A degree of detail quite unusual for this class of work was embodied in the drawings and information issued, so that even those firms who were not familiar with such work—some of them accustomed to a smaller class and others to the highest class of Admiralty work—would have no difficulty in knowing exactly what was required.

The advantages of manufacture to a common design were found of convenience in many ways as when, in the course of construction, one firm discovered defects in a soleplate casting; this was at once replaced by a similar casting from another firm, who were not at the time requiring that casting, failing which possibility delay of weeks would have occurred with the erection of the whole engine. Another instance was the facility with which a replace main steam pipe branch-piece was immediately despatched to a vessel ready for trial trip, when the original one showed leakage on the first steaming of the engines. The greatest advantages of this manufacture of details in multiple were, of course, experienced by the sub-contractors for these details, as they were thus enabled to proceed with a very large number of each article exactly alike instead of each differing, perhaps only in very small points, to suit the arrangements prepared by individuals, but sufficient to prevent them being used for the first firm requiring delivery.

It can readily be understood that many of the small items in a modern cargo vessel's engine-room could be manufactured to better advantage by specialists, than by large firms whose plant is generally suitable for large work, the items of which are different for each vessel, and especially so when orders for scores of these smaller items could be placed at a single time. The orders for all the auxiliary machinery, also the various valves, valve-boxes, branch pieces, cast-iron and wrought-iron pipes, &c., were consequently issued in multiple, from a single source, and placed with firms who specialise in such work so that once they had prepared patterns and templates to the drawings they could manufacture these fittings for all the vessels, drilled and ready to fit in place. For instance, the main steam pipes were finished complete by tube-makers to drawings, having been so designed that the unavoidable inaccuracies in fitting boilers and engines in place could be taken up at the joints and thus overcome the delay which otherwise invariably occurs through having pipes made to fit the place after everything else is in position.

The smaller castings for the main engines were also ordered in multiple, thus avoiding unnecessary patternmaking, as all the firms on the Clyde were supplied with those castings from two sets of patterns in all. This procedure enabled the machinery contractors to concentrate their attention on the bigger things with the knowledge that the smaller things were, so far as they were concerned, looking after themselves.

The positions of the auxiliary machinery were arranged so as to give the least work in completing the vessel after it was launched, the positions being so chosen that all erection could be completed in the shipyard before the launch, the various connecting pipes being of the simplest form while providing all the conveniences for working usually found in first-class work.

The feed filter, which is of the gravitation type using coir fibre, open to observation and replacement while the engines are working, is embodied in the main engine hot-well attached to the air pump, so that it is completely fitted in the engine works and no pipes and connections at all are required for it. The feed heater is of the well-known mixer type, and is also embodied in the main engine hot-well, the whole making a very compact arrangement with the minimum of fitting work. The evaporator is of the vertical type, capacity 25 tons per day, and conveniently arranged at the back of the main engines.

The winches are of the usual plain cargo-vessel type and number, arranged to exhaust to a winch condenser placed in the engine-room. The winch condenser is of ample size to deal adequately with the exhaust from the winches and so facilitate expeditious discharge of cargo. A general service donkey and a harbour-feed donkey are provided, both alike, of the single direct-acting type, with 9½ in. diameter steam cylinder, 7-in. diameter water cylinder, 18-in. stroke, and capable of feeding boilers in port or at sea, the harbour-feed donkey being fitted with automatic control from a float which operates with the water from either main engine air pump or winch condenser.

The ballast donkey is of the single direct-acting type, 11-in. diameter steam cylinders, 14-in. diameter water cylinder and 24-in. stroke, to quickly discharge water ballast from the various tanks throughout the vessel.

Owing to prevailing circumstances the use of copper piping had to be avoided. Wrought-iron has been largely used throughout, only the very small pipes being made of copper. As a result the total weight of copper piping is less than one-sixth of that usual in this class of vessel.

The boilers—three in number—are of the well-established multitubular return-tube type, 15 ft. 6 in. diameter by 11 ft. 6 in. long, for 180 lb. working pressure, working under Howden's system of forced draught. They do not present any special features, although it may be mentioned that the original design, prepared for the minimum amount of workmanship and expeditious construction, had to be modified in later boilers on account of the present demands on steel works for large plates, so as to enable those available to be utilised. The principle of manufacture in multiple was adopted for boiler parts also, this applying to such items as tubes and furnaces, the latter being finished to one set of templates for all firms.

THE "RUSTON" OIL LOCOMOTIVE.

In considering the possibilities of oil-driven locomotives, one finds few large fields in the industrial world, or at least in that realm governing "crude production"—where their introduction would not make for speed and economy. In this connection one might mention mines, quarries, brickyards and forests; tea, coffee, sugar, cotton, rubber, banana and other plantations; power stations, paper mills, cable works, breweries, factories, &c., and light railways and tramways. It is hardly necessary to lay stress upon their advantages to any of the above enterprises. The fact that they can start from cold at a moment's notice, and entail no stand-by losses, will commend them to certain classes of industry, such as quarries, brickyards and factories. That by their use the inconvenience of having to transport large quantities of fuel and water for their own consumption will commend them to the managers of timber concessions and portable railways, which, mostly established in remote regions, have long experienced this bugbear of coal fuel transport service.

The fact that they are absolutely safe as regards sparks, has already attracted widespread notice, and their immediate installation in timber concessions, powder factories and mines is a foregone conclusion, as by their use there is no danger of sparks setting fire to trees, or inflammable gases or material, as has been too often the case with the use of coal or wood-fired locomotives. That the British Government is now running four in one factory is in itself sufficient assurance, not only of their absolute safety in this respect, but also as regards freedom from breakdown, and all-round adaptability.

To all, the fact that they need no skilled labour, and that any man or girl of average intelligence can run them with ease and safety, should point a way to getting the better of ever-recurring transport and labour trouble, especially as only one man, or one girl, is required to run the locomotive.

In the Government powder factory referred to above, there is a railway system of 1¼ miles in extent equipped with four Ruston oil locomotives, burning paraffin. Part of the track is old, and over it hand trucks were formerly pushed. It was the existence of this track which settled the question of gauge. It was necessary, in order to connect up two parts of the old track, to cross a river twice on swing bridges, while between the bridges a watertight concrete-lined cutting, and a tunnel under a main road, had to be made. The cutting and tunnel are close against, and parallel to, the river, the normal water-level of which is 3 ft. above rail-level at the lowest point.

The worst obstacle in this construction was the removal and relaying of the town sewer, which syphoned under the river and rose to the surface in a "swan-neck" across the line of the railway. To make matters worse, the nearest joint in the pipes was near the middle of the river, and the constant stream of navigation could not be stopped. Sufficient room, however, could just be given for one barge to pass outside the coffer dam.

The approaches to the tunnel are on a gradient of 1 in 60, this being the worst that the train has to tackle. At one end, the track leaves the river in an S-curve of 60 ft. radius in order to get a good approach to a swing bridge. The gradient is reduced to 1 in 100 at this place, in order to compensate for the curve. The pier in the river is simply a concrete block, on three 12-in. by 12-in. reinforced-concrete piles. The swing span is provided with a hand lever at the shore end, which not only locks the bridge, but at the same time puts down the signal on the fixed span to safety. Similarly, the operation of unlocking the bridge throws the signal to danger, and it is impossible to unlock it without operating the signal.

The minimum radius of curve on the old track is

25 ft., but on the new track there is nothing worse than 30 ft. radius. The 25-ft. curves are gradually being eliminated, as they are rather too sharp for the engine, which, however, makes little difficulty with the 30-ft. radius. The weight of rail used hitherto has been 20 lb. per yard on steel-pressed sleepers, but this has rather been chosen because so much of it already existed. For the extensions now in progress a 30-lb. rail on wooden sleepers is being used.

As regards the rolling-stock, the trucks are 12 ft. long, and are on bogey-wheel frames. The engine is capable of hauling nine loaded trucks, weighing 2 tons each, fully loaded over the whole course of the track. For regular working, however, the load has been limited to six trucks.

The construction of the Ruston locomotive, and its general appearance, will be appreciated from an examination of the illustrations on this and the opposite page. In Fig. 1 is a general outside view of the engine; Fig. 2, an elevation with the covers removed to show the mechanism; Fig. 3 a plan, similarly exposed; Figs. 4 and 5 show an engine in course of erection in the builders' works; Fig. 6 shows the frame laid on its side; while Fig. 7 is a view of the locomotive and train in the Government works, together with the female driver, whose figure supplies a scale to show the height of the engine.

In designing this locomotive the builders, Messrs. Ruston, Proctor and Co., Limited, of Lincoln, decided that the somewhat heavy, horizontal, slow-speed engine was far more likely to meet the demands of the case than the lightly-built, vertical, high-speed, easily-racked motor-car type of engine. It was realised that for continuous running and certainty of action the engine must be water cooled—a decision arrived at by the careful consideration of the causes leading to the breakdown of many locomotives with air-cooled engines.

The locomotive was therefore designed to be compact, low on the ground, and very rigid, with a heavily-built real locomotive framework, giving the great stiffness absolutely necessary to prevent racking, should the gauge spread, or the crossings or points get out of order, causing derailments, as it was found in the course of investigation that the lightly-built type could not withstand such accidents.

The locomotive (Fig. 1) is four-coupled, the two axles being coupled by a chain, which allows them much flexibility of motion. The rear axle is driven by a chain which passes over two sprocket wheels on the countershafts shown in Figs. 2, 3 and 4. Only one of the sprocket wheels can drive at a time, since they are driven by the dog-clutches seen to the left of them, and these clutches are so coupled to the lever which controls them that only one can be in gear at a time.

The gearing starts by a pinion A (Fig. 2) on the crankshaft next to the disc flywheel (Fig. 4); this pinion gears with a small wheel B on a short intermediate shaft (Fig. 3), and on this shaft there is a second pinion gearing with the large spur wheel C shown on the right in Fig. 4, and also in Fig. 2. This wheel C is on the shaft carrying the forward driving sprocket, and gears with a smaller wheel on the rear countershaft which carries the reversing sprocket. At the left-hand end of the rear shaft is a spur-wheel F gearing with a similar wheel G on the shaft carrying the forward sprocket.

The spur wheels at the right of the two sprocket-shafts are both loose, but either one can be coupled to its shaft by a coil clutch adjacent to it. Let us suppose that the large wheel C on the forward shaft (Figs. 2 to 5) is clutched, and the smaller wheel E, on the rear shaft, is free. The drive, therefore, passes to the forward sprocket, and the locomotive runs on the slow gear. The rear shaft runs idly, being driven by the tram G H at the left-hand end (Fig. 4). When the forward coil clutch is freed, and the rear clutch put in, the drive is then through the wheels C and F, and the wheels H and G again to the forward sprocket, which now runs at the top speed. To reverse, the dog-clutch on the leading sprocket is freed, and that on the rear clutch engaged.

It will be seen from the engravings on the opposite page that the locomotive is built with the weight and rigidity which are essential for the rough treatment which attends all railway work. Figs. 4 and 5 show this, while Fig. 6 reveals the solid construction of the frame. The levers are all arranged in the cab, and are so interlocked that it is impossible to damage the gear. The sliding pinions which need so much skill in motor cars are absent, and the machine makes no more demands on the intelligence of the driver than does an ordinary stationary oil engine.

THE INSTITUTE OF METALS.—The Council announce that the 1918 May lecture will be delivered by the Hon. Sir Charles A. Parsons, member of council, who will give an account of thirty years' experiments on the formation of diamonds. Papers or notes intended for the 1918 spring meeting should be in the editor's hands not later than December 31 next.

THE "RUSTON" OIL-ENGINED LOCOMOTIVE.

CONSTRUCTED BY MESSRS. RUSTON, PROCTOR AND CO., LTD., ENGINEERS, LINCOLN.

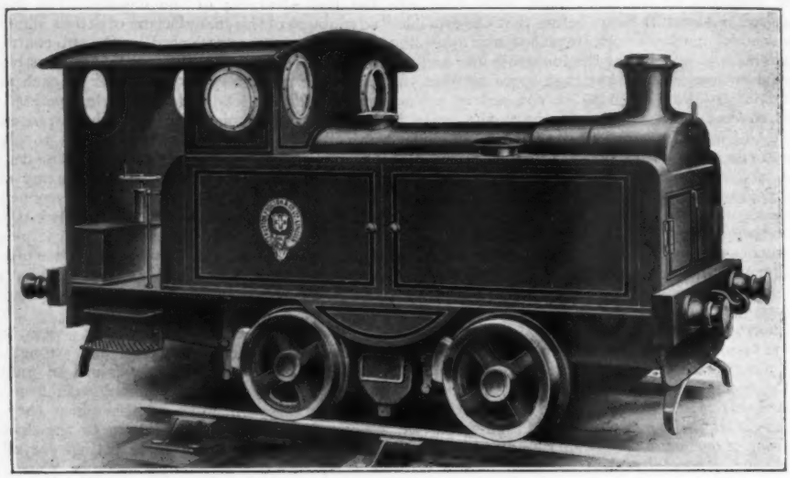
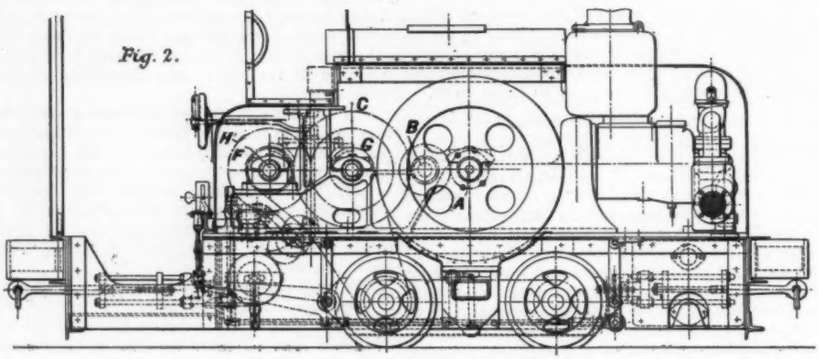
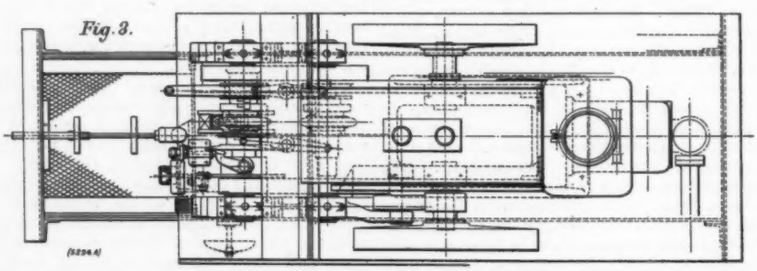


FIG. 1.





JAPAN'S ELECTRICAL MACHINERY TRADE.—H.M. Trade Commissioner in Australia reports, under date September 26, that the Secretary of Electrical Exploitations and the Bureau of Special Investigations, Tokio, recently arrived in Sydney with the intention of touring the Commonwealth in order to make inquiries in regard to electrical undertakings, with a view to studying the Australian market for electrical machinery and equipment, in the interests of Japanese manufacturers.

SHIPBUILDING IN GERMANY.—A German paper which may claim to be an authority as regards shipping and shipbuilding matters in Germany, estimates the capacity of the German shipyards in the years preceding the war at about 400,000 tons per annum; in 1913 the output amounted to 465,000 tons. After the war it must, of course, be taken for granted, that the majority of the German shipyards will be available for the reconstruction of the reduced German merchant navy. The capacity of these yards has been materially increased during the war and further extensions may be looked for. Four large shipyards have recently been founded, and almost all the existing yards have increased their share capital and extended their plant. During the war some 35,000,000 marks have been invested in the German shipbuilding industry, private capital having been forthcoming in sufficient quantity. At present plans are under consideration for the laying down of a North Sea yard, mainly for the building of motor driven vessels, and a yard on the Baltic is extending its capacity. The building capacity of the German shipyards may be taken as having increased 50 per cent. during the war, so that the annual production after the war, when normal conditions again prevail, will amount at least to 600,000 tons. Nor would it perhaps be wise to aim at a further increase in the production, inasmuch as it is not only a question of dealing with the years following immediately on the conclusion of peace, but also with a somewhat more distant future. For in half a score of years or so the demand for tonnage may have subsided materially. A condition set down is to the effect that all German requirements of new tonnage are to be provided for by German yards, and there is probably no reason for Germany to fear that such will not be the case, since most foreign yards will no doubt be fully employed with orders for their respective countries. The German shipbuilding industry, therefore, does not appear to be needed; but, on the other hand, every facility will have to be rendered it as regards the obtaining of sufficient labour and raw materials. Steamer concerns and steamer shares are not unfrequently changing hands. Thus a syndicate acquired some little time ago, through the medium of the National Bank of Germany, a number of shares in the Rickmers Shipping and Shipbuilding Company, and these shares, it is understood, have now been disposed of, with considerable profit to the vendors, to the Orient Trading Company, in Hamburg, which now controls all the shares in the Rickmers concern.

THE "RUSTON" OIL-ENGINED LOCOMOTIVE.

CONSTRUCTED BY MESSRS. RUSTON, PROCTOR AND CO., LIMITED, ENGINEERS, LINCOLN.

(*For Description, see opposite Page.*)

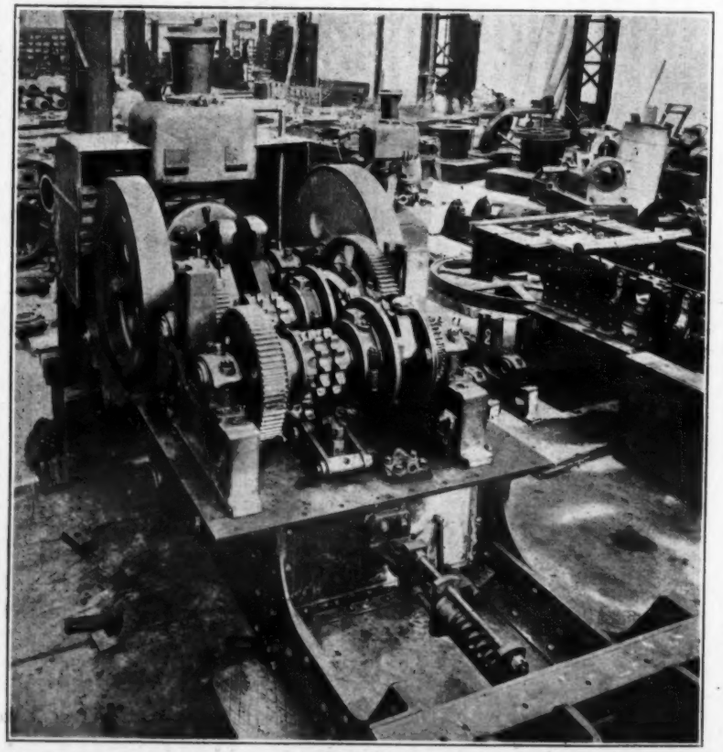


FIG. 4.

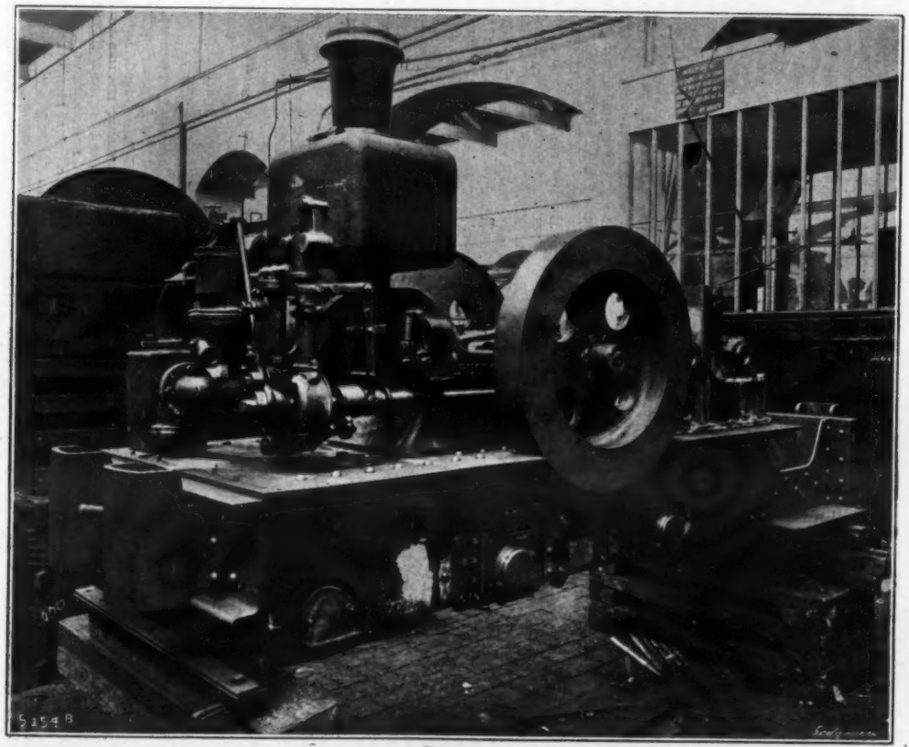


FIG. 5.

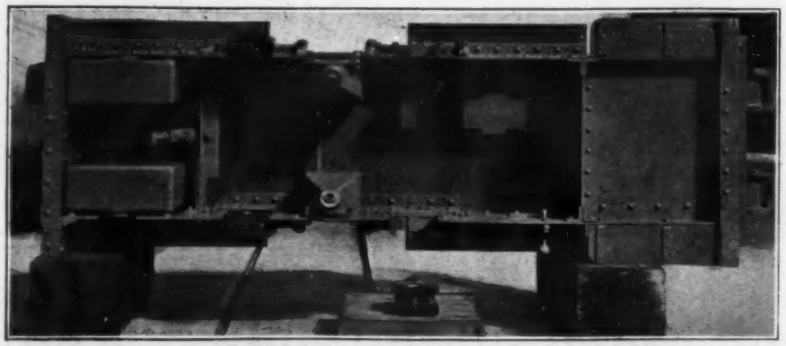


FIG. 6.

FIG. 7.

INDUSTRIAL NOTES.

Dr. Addison's announcement of an Advisory Committee to consider the Disposal of Surplus Government Property and Stores after the war is evidence of the determination of the Government to avoid scandals, loss and waste, the flooding of markets, derangement of trade and so on; the committee will also ensure that the things disposed of are allocated to the fullest and best possible use in view of national needs at the time.

War day by day consumes great quantities of the purchases—food, munitions, stores and the like—but when peace comes, many of them, including all the reserve stocks, and stocks "bought ahead" will be unconsumed. Other purchases of war, on the other hand, are not consumed from day to day, and will reach the day of peace but little impaired. As an illustration of this kind may be mentioned machinery, ships, and the Government's war properties of lands and buildings which now cover the vast area of approximately 470 sq. miles.

Some of these different war purchases will be needed for continued Government use; others may profitably be reserved for future use. But vast quantities will have to be disposed of. That so big a liquidation of war effects should take place without most earnest consideration and forethought would at any time be deplorable, but it would be doubly so at the close of the war, when so much of restoration and reconstruction will remain to be done with but limited supplies and means. Every available brick and beam and machine will then be needed, besides every ounce of food; for the shortage in these articles will not be made good merely by the signing of a treaty. And not only must every available item be used, but it must be allocated to the benefit of the nation as a whole. These, on broad lines, are some of the difficult problems of reconstruction with which Dr. Addison's Committee will grapple.

Dr. Addison's Committee will hasten on the preparation of inventories by the many Government departments having war stores and property under their control.

Then comes the question of ultimate use, when sale and place of sale have been decided upon. There will be many competitors for these stores and materials; concerns, public and private, are deferring work and extensions through lack of materials. But the nation, too, will have urgent national work on hand. A shortage of workers' houses exceeding 300,000 will have to be faced; shipbuilding will be a vital need, also land settlement and increased agriculture; many railways and public concerns will have repairs and renewals to do; there is a talk of new canals and other ventures. It is clear that some order of priority of claim will have to be determined.

The use of war transport lorries for agricultural and commercial purposes is an opportunity for the alternative peace use. Examples from the war zone itself show that the finding of alternative uses for war materials offers an immense field for ingenuity and research.

The Lords Commissioners of H.M. Treasury and the Minister of Reconstruction have appointed a committee to consider the report whether the normal arrangements for the provision of financial facilities for trade by means of existing banking and other financial institutions will be adequate to meet the needs of British industry during the period immediately following the termination of the war, and, if not, by what emergency arrangement they should be supplemented— regard being had in particular to the special assistance which may be necessary: (*a*) To facilitate the conversion of works and factories now engaged upon war work to normal production; (*b*) to meet the exceptional demands for raw materials arising from the depletion of stocks.

The Committee on Financial Facilities after the War which Dr. Addison, Minister of Reconstruction, has appointed in conjunction with H.M. Treasury, will have an important place in national reconstruction. There are 5,000 factories now working upon munitions alone, which will be returning to their peace-time work, and no matter how skilfully and speedily they may readjust themselves it seems inevitable that there should be at least some intervening period of unproductiveness. The cost of this re-conversion, moreover, will have to be faced. There is a further factor which will increase the financial strain. Most branches of the nation's trade commerce and industry will be faced with the necessity for greatly increased capital outlay in other directions. Raw materials will have much increased in price as compared with pre-war days, wages-rates to be paid will be higher, the values of stocks-in-hand and of stocks out on credit will be greater; it may even be that longer credit—especially in some branches of overseas trade—will be necessary. These causes, which are a few of many, will combine to make much larger demands than formerly upon the working capital of business firms of almost every kind and to keep it locked up for longer periods.

The committee of experts will go thoroughly into the matter and give the nation and the Government the benefit of their considered view after all procurable evidence has been sifted. Its members are direct representatives of the financial interests, banking, commercial and industrial, most concerned in the results of the inquiry; and they are drawn from many areas.

With reference to the 12½ per cent. increase to plain time workers in the engineering and shipbuilding trades the Government have decided to appoint a committee to interpret Orders regulating the matter, with a view to settle to whom they are to be applied and to smooth over difficulties generally in regard to their interpretation. The committee will consist of representatives of the Ministry of Munitions, Ministry of Labour, Admiralty and War Office. Any communications should be forwarded to The Chief Industrial Commissioner, Ministry of Labour, Montagu House, Whitehall, S.W. 1.

The Ministry of Munitions states that the War Cabinet has decided that the bonus of 12½ per cent. on earnings shall be paid to men aged 21 years and over employed on munitions work as plain time workers (and not otherwise), skilled, semi-skilled, or unskilled, in shipbuilding and ship-repairing, and that the bonus of 12½ per cent. on earnings already given to certain skilled men under the skilled Timeworkers Wages Order of October 13 shall be paid to men aged 21 years and over, employed on munitions work, as plain time-workers (and not otherwise), skilled, semi-skilled or unskilled, in engineering shops, boiler shops and foundries, whose wages it has been the practice to regulate by the movements in wages in the engineering and foundry trades. The bonus will be payable as from the beginning of the first full pay following October 12, 1917.

The Order carrying out the details of the above decision will be issued as early as possible, and until it is issued, no payments are to be made.

Speaking in Parliament, on Wednesday last, Mr. Churchill said the War Cabinet decided to grant the 12½ per cent. advance on a wide basis to skilled time-workers, and the Ministry of Munitions accordingly issued the Order of October 13. It was always intended by the War Cabinet that a similar Order should be made in regard to shipyards, and the original estimates of cost submitted to the Cabinet by the Ministry of Munitions covered both the skilled engineers and moulders and skilled shipyard workers. This involved about 300,000 men, and the consequent increase in the cost of production which falls indirectly upon the State was estimated at 6,500,000*l*.

After further consideration by War Cabinet conferences, the War Cabinet decided to extend the 12½ per cent. advance to all time-workers on engineering work or munitions and in the shipyards. This further advance covers an additional 600,000 men and adds an additional 7,500,000*l*. to the annual cost of production.

A representative deputation of employers and workmen engaged in shipbuilding has recently been received by the Prime Minister at Downing-street, when they placed before him their joint suggestions as to the best means for securing the greatest possible output of new ships. The deputation was introduced by Mr. A. Wilkie, M.P., of the Ship Construction and Shipwrights Association, and the joint proposals were put forward by Sir George Carter, representing the employers, and by Mr. J. Barker, of the Boilermakers' Society, representing the trade unions.

The Prime Minister, in the course of his reply, said: "This is quite a unique deputation, and may well mark a very important step forward in the industrial relations of this country. It is a deputation of the leading employers and of the workmen's leaders to press upon the Government certain considerations which involve joint action between employers and workmen. That in itself is an event, and an event of very considerable significance. It is one of the most encouraging features in the prosecution of the war, because without a good understanding between the employers and the workmen the prosecution of the war becomes very difficult. It is a matter for considerable gratification that a desire should be expressed by employers and workmen for the setting up of some body representative of both, which will be an efficient instrument in the settling of all difficulties and disputes. Naturally you do not want to bring these up to Government departments if you can settle them amongst yourselves, for the simple reason that a settlement made by the workmen and the employers is in itself, from the fact that it is a settlement made by them, a settlement which indicates a more perfect goodwill and satisfaction. I hope this is the beginning of very big things in the way of getting a better, a more complete, and a more permanent understanding between the employers and the workmen in the vital industries of the country; because without that understanding there is nothing but trouble, distraction and loss of production.

"That we cannot afford. We are fighting for our lives. We have terrible struggles on land before us, but if we are secure on the seas, well, to use a phrase, we have 'got them'; they cannot escape us. We have got them in a deadly grip, and knowing the character of the people of this country as I do, they do not let go once they have started. That is their historical character, and the German knows it. He is aware that our grip is a deadly one once we begin, and he is trying to unloosen it. He is attempting to get us at what he considers is the most vulnerable point, namely, our communications on the seas. He will not succeed, but it depends very largely on you employers and you leaders of the men, and you can only get the best results by goodwill and co-operation and by throwing the whole of your energy and strength into the task.

"I cannot tell you how cheered I am by the fact that you have come here to say: 'We want to work together, we want to settle our disputes amongst ourselves, and we want the Government departments to cease overlapping and to assist us to do the work.'

"That is the way in which we will win, and I want you especially to try to prevent the little disputes which concern neither the employer nor the Government—little disputes between various trades on questions of demarcation—from stopping the work. You know it is a great misfortune that it should happen. It really does not matter to you whether a carpenter does the work or a joiner does the work. But there are little things of that kind happening, and the great thing is that somebody should do the work and should do it without any loss of time. Therefore I want you to use the influence of your great unions to prevent disputes of that kind interfering with the output."

Speaking last Saturday at a meeting of the Sheffield Workers' Educational Association, Mr. W. L. Hichens, chairman of Messrs. Cammell, Laird and Co., said it would not be humanly possible to find jobs straight away for the men who came from the front. They would find their munitions works stopped, and those who had been toiling at munitions would find there was a certain transition period before peace industries were started going again. It would be the business of everybody to make that transition period as short as possible. It was no use saying they would eliminate the employer altogether; the employer would not be there if he did not serve some useful purpose. In the course of time some better system might be found, but until then it would be highly dangerous to advance along the line of destruction.

The first fundamental change was to get away from the idea that industry was primarily a profit-making affair; it was national service due by employer and workman to the community or State for the privilege of living within its borders. He agreed, of course, that the idea of material reward could not be eliminated altogether. Yet this was not the highest, the best, or the final thing. Capital must not be allowed unlimited profit. If, after the necessary charges for labour, material and so forth, capital was paid all the rest, that was fundamentally wrong. It seemed to him that capital was entitled to a fair return on its money. He was not going to argue whether capital was necessary or not; he could not see that they could do without it. But capital was not entitled to unlimited reward. All over what was regarded as a fair return must be a subject for excess profit taxation.

Siimlarly, labour was not to be entitled to hold the community up to ransom by a "corner" of the labour market. It was a wrong conception that labour had a right to whatever it could wrest by force out of the capitalist or the consumer. Labour, like Capital, was entitled to a fair share in relation to the rest of the community, but no more. What was fair could only in the last resort, failing mutual agreement, be determined by the representatives of the community as a whole, that was the State. It was vital also that the decision so reached should be accepted as binding and obligatory, otherwise the position was little removed from anarchy. There were three partners, Labour Capital, and the State, and nothing done by one could be fair unless it was fair to the other two and to the whole.

Restriction of output, Mr. Hichens added, was one of the most serious problems to face. If we could get rid of all restrictions of output, and if we were allowed fair play for the introduction of every mechanical device which would save labour we would open up an era of great prosperity in this country.

We understand that Messrs. Dorman, Long and Co., Limited, have purchased the whole of the interests of Messrs. Sir B. Samuelson and Co., Limited. They thus become the owners of the eight blast-furnaces and coke ovens hitherto belonging to Messrs. Samuelson, known as the Newport Ironworks, Middlesbrough, and of several iron ore mines and collieries.

Mr. Kellaway, replying, in Parliament, to Mr. Pringle, who asked what was the result of the abolition of leaving certificates under the Munitions of War Amendment Act, stated that there had been no widespread and abnormal movement of labour since October 15, and, in consequence, no general dislocation of work as a result of the repeal of Section 7 of the Munitions of War Act, 1915. Considerable movement had, however, according to his information, taken place in certain skilled occupations, more especially tool-room men. The effect of this would not necessarily appear in output for some little time. The application for transfers in shipyards had been very low. Such movement as had taken place had varied a good deal according to localities, certain isolated areas having suffered more than others. There was a tendency in some quarters for men to use their freedom as a lever for securing higher wages. He had also received a number of complaints of firms offering inducements to workmen to leave their employment contrary to Regulation 8B of the Defence of the Realm Regulations. He was advised that the action of the Government in agreeing to the payment of a bonus of 12½ per cent. to men engaged on time on munitions work had had a marked effect in reducing the movement of labour. On the whole, it might be said that the abolition of the leaving certificate had not been attended by evil consequences to the extent that was anticipated, and that an undoubted cause of discontent and unrest among munition workers had been removed.

Conferences of the National Union of Railwaymen have been in progress at Leicester and other cities during the last fortnight to uphold the men's claim for a 10*s.* per week advance on their present wages. The Railway Executive offered a 5*s.* advance per week. which the men have refused, insisting upon receiving the full 10*s.*, their original demand. In the meantime, the Liverpool railwaymen decided to work on the "slow-gear" method, and their action led to the breaking-off of all further negotiations by the railway companies, acting with the support of Government.

A labour dispute which started at Coventry a few days ago still continues, and as a consequence, a large number of workers, men and women, employed on the production of aircraft and other munitions of war, are idle. The Ministry of Munitions issued last Monday a statement to the effect that an award was given on October 30 by an arbitrator appointed by the Ministry of Labour, on certain wages questions arising at the works of Messrs. White and Poppe. A question as to the interpretation of the award arose and as a result a "stay-in" strike followed. Messrs. White and Poppe indicated their willingness to discuss the points at issue with the men. The men, however, demanded that the firm should treat with the shop stewards; the firm pointed out that the question of the recognition of the shop stewards was under consideration by the legitimate union officials and the Employers' Federation, and that in these circumstances they could not recognise the Shop Stewards Committee as such. The men did not accept this decision; the question spread to Coventry generally, and a demand, backed up by the present strike, has been formulated to the effect that employers in Coventry should deal with the Shop Stewards Committee generally. The unions principally concerned have discountenanced the strike, and have advised the men to return to work in order that the question at issue may proceed to a conference with the employers in accordance with the agreement in existence between them for the purpose of dealing with trade disputes.

Russian Industry Difficulties.—The Russian industry has fared very badly during the last six months, and a great many factories have been compelled to close down. According to official statistics, 568 factories, employing 104,372 hands, were obliged to stop work between March 1 and August 1. It will be seen from the number of hands employed, averaging 183 hands per factory, that they are mostly small or medium-sized concerns, coming under the following heads, among others: Articles of food, corn mills, &c., 196 factories; metal industry, 91; timber industry, 76; cotton industry, 49; mineral undertakings, 44, &c. The largest number of hands out of employment comes under the cotton industry, viz., 53,417 hands, and in this branch it is the largest undertakings which have been compelled to stop work. The movement, if one may so call it, has diverse causes, shortage of raw materials and fuel, excessive demands for wages, &c., and the number of concerns which are closing down is steadily increasing.

FOREIGN SHIPBUILDING ACTIVITY.

The U-boat has not been altogether disastrous to the neutral nations. It has certainly sunk a good many of their vessels, but these have been covered by insurance, and freights have been so high that the premiums could be paid with ease. Many old ships have been insured for several times their original cost, and their loss has given rise to no regret. On the other hand, the neutral shipbuilders have been besieged by prospective customers, and have had no difficulty in securing splendid prices. Holland, Denmark, Sweden and Norway can sell all the ships they can build, and could they obtain steel and labour their output would, in the aggregate, be very great. They are doing their best under difficult conditions, and they are also making preparations for the day when the demand for shells and guns will cease and a great weight of metal will be available for industrial uses. The following notes give some clue to the prospective activity in shipbuilding on the declaration of peace.

The new Nakskov yard, Denmark, although begun on a modest scale, has already secured more land. Both wood and steel ships are being built; for the latter three slips are being provided; the first, which is about ready, will at once be taken in use for a 3,000-ton boat; slip No. 2 will be ready in the course of a few months, and is designed for vessels up to 8,000 tons, and a third slip will be for 10,000-ton boats. A garden city is in course of construction for the men. The Kallundborg shipyard, another new Danish venture, is doubling its capital, from 55,000*l.* to 110,000*l.* The Landcrona yard, on the Sound, on the Swedish side, is progressing rapidly. The workshop is ready, and two slips for vessels of 4,000 tons to 5,000 tons, one having already been taken into use. The large dock, 621 ft. long, 88 ft. broad, capable of accommodating vessels of 15,000 tons, is to be ready on August 31, 1918. A slip for 15,000-ton vessels is also in course of construction, and a fourth, for vessels of 20,000 tons, will also be added. The full capacity of the yard is calculated at 80,000 tons per year, with a staff of some 2,000 men. The Reicherstieg yard in Hamburg earned gross profits for the year 1916–17 amounting to 4,148,306 marks, against 2,836,078 marks. Writings-off amounted to 1,127,661 marks, or about twice as much as during the previous year. The shareholders receive a dividend of 8 per cent. and the capital has been increased by 1,000,000 marks for the purpose of acquiring the neighbouring Wichorst yard.

In Chili, efforts are being made to promote the shipbuilding and kindred industries, and it is proposed to grant premiums for shipbuilding, both for wooden and steel ships, for sailing vessels and for boats with auxiliary motors, according to a sliding scale. Also the makers of engines are to have premiums per horse-power. Floating docks of steel for home or foreign account receive 30 pesetos (45*s.* in gold) for each ton, which can be lifted, and the amount is raised to 40 pesetos for the first two docks, built in Chili and capable of lifting 8,000 tons each, to be used in Chili after the passing of the Bill; also the machinery for the docks receives a premium. Vessels, docks and engines built for account of the State are exempt from the above regulations. The measure is intended to be in force for 10 years for docks and 15 years for vessels and machinery.

In Japan, shipbuilding is progressing as never before. During the first half of the present year there were completed at Japanese shipyards 31 steamers of more than 500 tons, with an aggregate tonnage of 108,755 tons; before the end of 1917, 66 freight steamers will have been completed, making a total of 97 steamers with an aggregate tonnage of about 400,000 registered tons gross. In 1918 alone at the Kawasaki dockyard 20 cargo steamers of 180,000 tons, and worth about 72,000,000 yen (7,350,000*l.*), will be built, and most of these are understood to have been sold to England. Since the beginning of the war 32 steamers of 133,761 registered tons gross have been sold to England, France, Italy, America, Spain and Norway, at an aggregate price of some 85,000,000 yen (8,700,000*l.*). In addition some 90 fishing vessels have been delivered to foreign countries, their value being put at 15,000,000 yen. Besides the large sums which have thus been realised by the disposal of tonnage, Japan has earned vast amounts by chartering her vessels to her Allies and in some exceptional cases also to neutral countries. About 50 cargo steamers, of an aggregate tonnage of 178,104 registered tons gross, are being used in the Indian Ocean, the Atlantic and the Mediterranean. Some Japanese boats are also trading on the Pacific for American account. Japan's revenue from these sources the last two years amounts to 60,000,000 yen (6,100,000*l.*) per annum. In May, 1917, the Japanese mercantile navy comprised 2,104 steamers of an aggregate tonnage of 1,691,795 tons gross and 9,573 sailing vessels of 5 registered tons gross or more, with an aggregate tonnage of 604,174.

The Hongkong shipbuilding industry, states a Norwegian consular report, has been rapidly progressing during the war, but nearly all the materials, both for the hulls and the engines, have had to come from Europe or America, which has materially increased their cost. So as to be more independent in this connection the Hongkong Steel Foundry Company is being extended. The largest yards are the Taikoo Dockyard and Engineering Company and the Hongkong and Whampoa Dock Company. The former yard was established some 10 years ago, and is quite modern. It has a dry dock 787 ft. by 88 ft. by 34½ ft. and three slips. The yard has just delivered a boat of about 8,000 tons, and the keel has been laid for a sister vessel. The Hongkong and Whampoa Dock Company is a much older concern, started about 50 years ago, but extended and modernised several times since. It employs about 6,000 hands and has an excellent reputation as a repairing establishment, with its six dry docks and two slips. The largest of the dry docks is 700 ft. by 86 ft. by 30 ft., and can accommodate the largest vessels at present trading in Hongkong. The yard is at present undertaking extensions to receive larger vessels.

Swedish shipping concerns have at present 55 vessels ordered from Norwegian yards, of an aggregate tonnage of 142,000 tons gross. Of these boats six are twin-screw boats to be fitted with Burmeister and Wain Diesel motors, and three are to be fitted with Ljungström turbines.

Ferro-Concrete Shipbuilding. — The Porsgrund Ferro-Concrete Shipyard, which has attracted so much attention through its ingenious method of launching, has decided to construct slips for the building of ferro-concrete vessels of 4,000 tons. According to the present plan the construction of ships of this size is to commence during the summer of 1918. In Holland, a company has been formed for the starting of a ferro-concrete shipbuilding concern, and in Denmark, where some isolated work has already been carried out on a more modest scale, negotiations are pending with a view to start a rational ferro-concrete shipbuilding industry.

Construction of Electric Locomotives in Manchuria.—H.M. Consul at Dairen has forwarded, under date September 14, a copy of the specification of an electric locomotive which has recently been built at the South Manchuria Railway Company's works at Shakako, for the use of the Fushun mines. It was proposed to build seven other locomotives of a similar character by the middle of November. It is understood that this is the first attempt to build this kind of locomotive in Manchuria, supplies having hitherto been obtained from Germany or the United States of America. British firms interested may consult the specification at the Department of Commercial Intelligence, Board of Trade.

The Victorian Government Railways.—The Department of Commercial Intelligence is in receipt of a copy of the Final Report of the Royal Commission on the working of the Victorian Railways as a Business Undertaking, from which it appears that there were losses in the receipts of the railways, as compared with expenditure, for the years 1914–15 and 1915–16, notwithstanding in the latter year a record gross revenue and a record revenue per train-mile. There was also a deficit in the estimated receipts for the year 1916–17. The occurrence of these losses for the years mentioned, following a number of years in which substantial surpluses were shown in the State railway accounts, led to the appointment of the Royal Commission to inquire into and make recommendations with regard to the operations of the railways. The Commission found that: (1) Having in view the abnormal conditions of the last three years, which conditions are still in force, the Victorian Railways are administered with due regard to economy, efficiency and the public convenience; and (2) the deficits in the railway accounts have been largely brought about by influences beyond the control of the Railway Commissioners. With regard to proposed economies in working, the Commission makes several suggestions. Chief among these are proposals for the suspension of the construction of new railways, and the reduction of expenditure on lines in course of construction at the present time to the lowest possible limits. It is further suggested that a considerable saving could be secured, especially as regards goods and mineral traffic, by increasing train loads and using more powerful locomotives. It appears, however, that nothing approaching a really heavy engine for goods and mineral traffic is available. Evidence was given before the Commission that 50 engines of the "Consolidation" type could be utilised with advantage on the State Railways, and that an annual saving in operating costs of not less than 25,000*l.* would probably be effected thereby. It was also stated that only some 14 engines are provided with superheat boilers; but that, had not the war occurred, some hundred engines of the A2 and DD types would have been so equipped. The recommendations of the Commission with regard to engine equipment economies are: (*a*) That the construction of locomotives of the "Consolidation" type be proceeded with as rapidly as the financial position and the difficulty of obtaining materials will permit; and (*b*) that all locomotives of the "Consolidation" A2 and DD types be built to use superheated steam. The copy of the report referred to may be consulted by British firms interested at the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2.

SELF-TIPPING LORRY FOR THE CITY ELECTRIC LIGHT CO., BRISBANE.

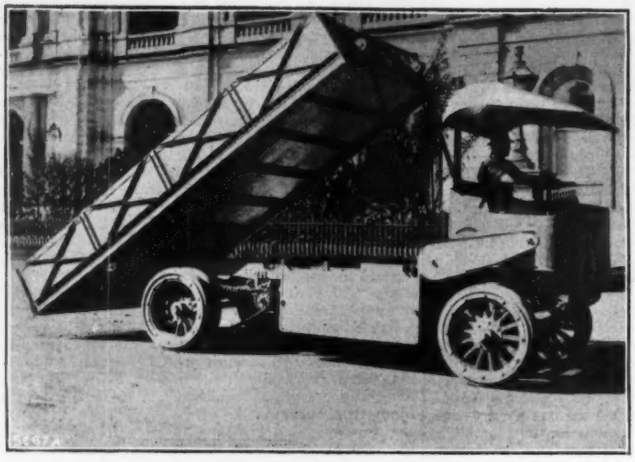


FIG. 1.

FIG. 2.

THE City Electric Light Company, Limited, Brisbane, Australia, have put into service a 5-ton electric self-tipping lorry for the purpose of carting coal from the Roma-street railway coal shutes to their power station in William-street, a distance of approximately 1¼ miles. The lorry, of which we publish two views on this page, weighs approximately 10 tons when loaded, and is propelled by an electric motor, operated from a 44-cell Chloride Company's iron oxide storage battery. Its range, when loaded, is 45 miles on one charge, with a speed of 7 miles per hour.

The body of the lorry can be elevated to an angle of 45 deg., and is therefore self-emptying, it is filled by gravity at the coal shutes. The elevating of the lorry body is done by a 3-h.p. electric motor driving, through gearing, two vertical screws. It takes less than 1 minute to reach maximum elevation. The chassis was supplied by the General Vehicle Company of America, through their Australian agents, the Australian General Electric Company, but the body and elevating gear were designed and built in Brisbane. The lorry and its driver are now handling 50 tons of coal daily, and have replaced eight tip drays. The average consumption of electricity by this lorry, taken over one month, was 2.43 units per mile of route.

The electrically-operated lorry has a great future before it, and in this case at least proves that the large capacity motor lorry can do excellent and economical service.

NOTES ON AIR-LIFT PUMPS.—In our report of the reply of Mr. Arthur Purchas to the discussion of his paper on "Air-Lift Pumps," before the Institution of Mechanical Engineers, the figure 62 was, by a typographical error, substituted for 72. The sentence (page 558, third column) should read "As to the claim he had made for a possible efficiency of 80 per cent. for the air-lift plant, he would point out that the figures actually recorded showed 72 per cent."

THE LATE MR. JAMES BUCHANAN.—We regret to have to record the death, which occurred last week, of Mr. James Buchanan, managing director of the well-known Liverpool engineering firm, James Buchanan and Son (Liverpool), Limited, Caledonia Foundry and Engine Works. Mr. Buchanan was admitted a partner in the firm in 1877, and under his direction the business made steady and considerable progress, the works being now one of the most important industrial concerns in the district. He was a recognised authority in sugar-making and sugar-refining machinery, and in this connection he acted as consultant for a number of the largest sugar refineries at home and abroad. Mr. Buchanan was associated with the executive of the Liverpool Munitions of War Committee and the sub-committee for the manufacture of shells and fuses, and at the outbreak of war he undertook important Government contracts, installing an extensive plant for the production of munitions of war. This special department employed a very large number of hands and is one of the largest of its kind in the district. He was a past-president of the Liverpool Polytechnic Society, president of the Liverpool Engineering Employers' Association, a member of the executive council of the Engineering Employers' Federation, of the Institution of Mechanical Engineers, the Society of Chemical Industries, and other scientific societies. He was a man of outstanding characteristics and keen, sound judgment, and his loss will be keenly felt by the numerous bodies with which he was connected.

THE ESTABLISHMENT AND MANAGEMENT OF ENGINEERING WORKS' CANTEENS.*

By ARTHUR F. AGAR, Organising Inspector, Canteens Committee Central Control Board (Liquor Traffic), London.

AT the very commencement of the Canteen Movement, it was apparent that considerable extension and improvement of the existing facilities for feeding the workers was imperative. This duty of establishing and generally of organising canteens was entrusted to the Central Control Board (Liquor Traffic), whose chairman, Lord d'Abernon, has always taken a keen interest in the constructive work of canteen provision. A committee of this board called the Canteen Committee was formed in 1915, and Sir George Newman, M.D., chief medical officer of the Board of Education, was appointed chairman.

It was found that, comparatively speaking, only a few Industrial Canteens were in existence; if any provision was made at all it was simply to provide some kind of a room, with possibly warming-up and hot water apparatus, in which the workers could partake of any food brought by them. Even this in many cases was totally inadequate, and consequently those workers who did not go home to meals, or to neighbouring cookshops had to have them as best they could in the different workshops. The Canteen Committee drew the attention of the Ministry of Munitions to the desirability of making adequate canteen provision in the national munition factories established throughout the country, and canteens were included in their plans. This has proved a very strong asset towards the development of the canteen movement; another factor of assistance was the concession to the controlled firms by which the construction and equipment of a canteen can be charged against the earnings of an establishment during the period of control if it is approved by the Committee. The voluntary associations also gave considerable help to the inauguration of the movement, and the Central Control Board is authorised by the Lords Commissioners of the Treasury to pay grants in aid equal to 50 per cent. of the capital expenditure incurred by such societies on the provision of canteens for munition and transport workers.

All this has, of course, been of the utmost value, but it has been found that the employer, occupied as he is with the dominant question of output, would not so readily have availed himself of the opportunity of establishing a canteen unless assured that he could receive expert guidance in planning, equipping and organising his canteen. Fortunately the committee is in a position to give this, and its services have always been fully at the disposal of employers, whether controlled or otherwise. To-day the committee has knowledge of 700 canteens in existence in docks, in national factories and controlled establishments, and I think you will agree with me that these figures speak for themselves as regards the efficacy of the committee's methods.

I propose to discuss the subject under two headings: First, "The Establishment of a Canteen"; second, "The Management."

Seating Accommodation.—The first consideration is the number of persons the canteen will be required to seat. To decide upon this, it will be necessary to find out the maximum number who are in the habit of remaining at the works for meals during any meal interval. It may be that more will require provision for breakfast, or perhaps dinner, or if a night shift is in operation the accommodation required then will possibly be the greatest. This figure can be taken as a basis to work upon, but it must not be overlooked that it is hoped to provide for a proportion of those who at present go to the coffee shop, or even of those who go home. Personal investigation by the officials of the firm is the most trustworthy: workpeople are notoriously shy of filling up any forms which they think may commit them in any way.

Construction.—The site is very important; it should, of course, be in a central position, easy of access from all parts of the works. The design should be as attractive as possible, not a barrack-looking building, but one with agreeable lines. The canteen should include dining-room or rooms, kitchen, scullery, larder, stores, catering office, and sanitary accommodation. The stores and larder, &c., should open on to a yard, with easy access, for tradesmen's carts, &c. As the system of service would be what we call a counter-service, *i.e.*, the workers fetching their meals from the service counter to the tables, the kitchen and scullery should abut direct on to the dining-room. The size of the dining-room may be calculated by allowing from 8½ sq. ft. to 9 sq. ft. for each person whom it is desired to seat.

The following inexpensive permanent construction has been found suitable:—Walls: 9-in. brickwork rendered externally with Portland cement ¾ in. thick, and finished with a rough cast surface; with large span roofs, brick piers of greater thickness will be required under the roof principals. The brickwork internally to be flat-pointed, with a painted dado to a height of 5 ft., the brickwork above distempered, no plaster being used. Roofs: Boarded and covered with slates, the underside of boarding being painted a cream colour. Floors: Concrete with granolithic face.

Cooking Apparatus.—The efficiency of the cooking and economy in running expenses in a canteen depends to a very large extent on the wise choice of the cooking apparatus. Cooking by gas, coal or steam is most in favour, whilst in some canteens one finds electricity as the cooking factor. A good plan is to furnish the different cooking apparatus manufacturers with particulars of the number to be catered for, leaving them to submit a scheme for the apparatus.

As a guide I give the following particulars:—

For 100 persons: One double-oven range for roasting and baking, with hot plate for boiling, frying, &c.; one hot closet and warming cupboard, about 48 in. long by 30 in. high by 24 in. deep; one 15-gallon boiler for vegetables, &c.; one 15-gallon boiler for tea water, washing-up, &c.

For 250 persons: One three-oven range for roasting and baking, with hot plate for boiling, frying, &c.; one hot closet and warming cupboard, about 72 in. long by 30 in. high by 30 in. deep.; one potato and pudding steamer; one 20-gallon boiler for vegetables; one 25-gallon boiler for tea water; one 10-gallon boiler for soup; boiler for supplying hot water through the sink taps.

For 500 persons: One large roasting oven; one three-oven range; hot closets and warming cupboards to form part of each serving counter; carving table with hot closet under for warming plates; one potato steamer; one pudding steamer; one 25-gallon boiler for vegetables; two 25-gallon boilers for tea water; one 20-gallon boiler for soup; boiler for supplying hot water through the sink taps.

Teak sinks are generally found more suitable for washing up crockery, as tending to minimise breakage, than the ordinary sinks of glazed fireclay. These latter can be used for vegetable preparation, &c.

Equipment.—The following basis of calculation may be of assistance to determine the original equipment for a canteen:—Knives, forks, spoons (dessert and tea), cups and saucers, one for each person seated, allowing for a few dozens over; plates, double the seating accommodation. The same size of plates should be used for meat and pudding. Tumblers, egg cups, soup bowls,

* Paper (slightly abridged) read before the Manchester Association of Engineers, November 24, 1917.

and small plates, half the seating capacity; jugs, sugar basins, mustard pots and salt cellars, tablespoons, about one-tenth of the seating capacity.

Cost.—We generally take as a basis for calculating the cost of the building only about 5*d.* per foot cube, exclusive of central heating and lighting. Complete equipment should cost approximately:—47*s.* per head for 100 persons seated, 32*s.* per head for 500 persons seated, 30*s.* per head for 1,000 persons seated. Taking a canteen seating 500 as an example, the total cost, including the building and its equipment, should be in the neighbourhood of 7*l.* per seat. Smaller canteens cost rather more proportionately, and, of course, the nature of the site has a lot to do with the cost. For the plans embodying the principles already explained, see Figs. 1 to 3, on this page.

Management and Administration.—Generally speaking, the direct control of the majority of the canteens is in the hands of the employers themselves, with a manager or manageress under them, but in some cases the catering has been entrusted to an outside catering firm or voluntary society. It is rather early to say what will be the position of these voluntary societies after the war, found to be the best plan to leave them only in an advisory position. To avert any suspicion that the canteen is a means of exploitation, I would suggest that this committee should have ready access to the trading accounts, &c.

[The author next dealt with some detailed points of administration, giving hints as to service, staff, system of cash-keeping and book-keeping, buying, tariff]. The usual tariff obtaining to-day is: Cut from joint (2¼ oz. to 3 oz. cooked), 6*d.* to 8*d.*; made-up dish, 5*d.* and 6*d.*; vegetables, 1*d.* and 1½*d.*; puddings, 2*d.* or 3*d.*; tea, &c., 1*d.* The dinner menu generally consists of one joint, one made-up dish, two vegetables, and choice of two sweets.

The canteen should be open not only to purchasers of meals, but also to workers who may prefer to bring their own food. In some canteens a charge of ½*d.* a meal, or an inclusive charge of 2*d.* or 3*d.* per week is made for the use of the warming-up facilities. Whether there should be a charge at all is largely a matter of the local conditions obtaining in the particular district. In practice it is found that if the workers who bring their own food have an opportunity of seeing the good fare provided in the canteen they gradually cease from bringing food and become customers themselves.

Fig. 1. CANTEEN TO ACCOMMODATE 70 PERSONS.

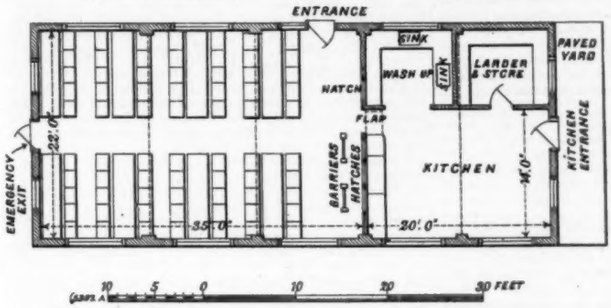


Fig. 2. CANTEEN TO ACCOMMODATE 300 DINERS WITH EXTENSION TO 400 DINERS.

The size of the Kitchen for 300 Diners would be 25 ft. × 20 ft.

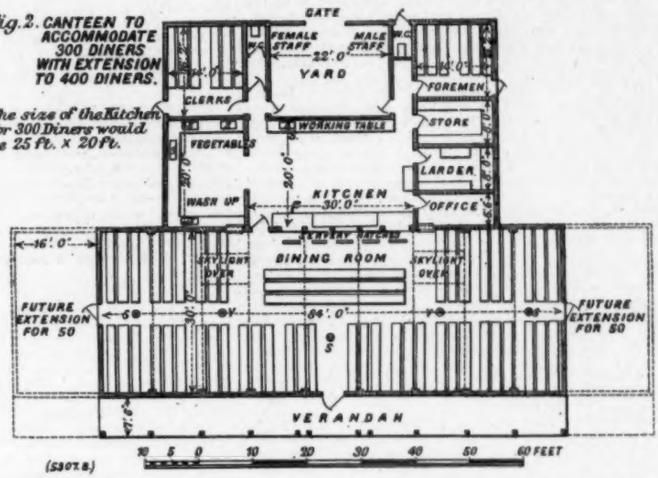
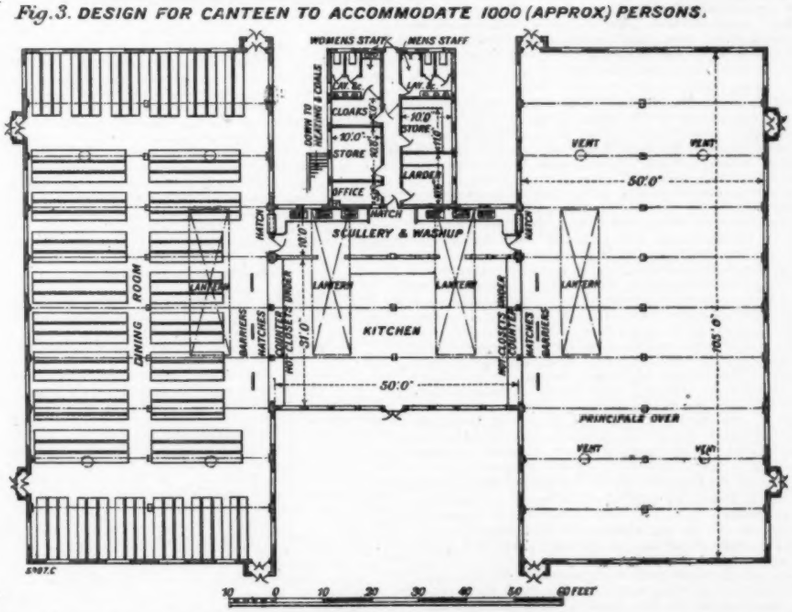


Fig. 3. DESIGN FOR CANTEEN TO ACCOMMODATE 1000 (APPROX) PERSONS.



The following table, issued with the concurrence of the Food Controller, shows the suggested portion to be allowed to each customer at each meal:—

	Meat. Oz.	Sugar. Oz.	Bread. Oz.	Flour. Oz.
Breakfast ...	2	½	2½	–
Dinner (or other principal meal)	5	½	1	1
Tea	Nil	½	2	1

The weight of the meat is the uncooked weight. Three ounces of flour is equivalent to 4 oz. of bread, and the two are interchangeable on this basis.

Profit and Loss.—No capital charges are included, nor are current charges coming under the heads of cost of structure, initial cost of equipment, rates, taxes and heating and lighting of the canteen. These are not charged against the canteen, the employer taking the view, and very rightly, that if he wants to sell food to his workers at a reasonable rate, the canteen account must not be unduly overburdened. It is also found that in many cases the employer is quite content to pay for the fuel for cooking and for the cleaning of the canteen, leaving the canteen practically only to bear the cost of the food and service. He soon finds that the added efficiency of his workers repays him for any concessions he may make.

Members will probably wish to know whether, after having paid for the structure, equipment, &c., and the other charges which I have specified, one can reasonably expect the canteen to bear the remaining expenses, *i.e.*, cost of food and service. My answer to that is "Yes," of course, provided that the tariff is not fixed too low. To-day the price of foodstuffs makes it rather a difficult matter, but it can still be done.

Conclusion.—Although the canteen movement was primarily instituted as a war measure, its success has shown that it has supplied a permanent need. It has come to stay, and when the war is over I look forward to the time when every fairly large employer of labour, at any rate, will include a canteen in his works programme as a matter of course. It is a sound business proposition, not a benevolent experiment, and it marks a distinct development of the better relations between employer and employed. It is an asset to the employer by reason of better timekeeping, more contented and efficient workers, and also it is a partial solution of the ever-present housing problem. With a canteen the employer is not restricted to establishing his works in already hopelessly overcrowded neighbourhoods, but can choose sites which afford scope for expansion and healthier and more roomy workshops. For the worker it is the tangible expression of his employer's desire to improve his conditions, not from a feeling of coercion, but of his own free will.

As regards canteens for works already established, I may be told that in some cases feeding facilities already exist in the form of cookshops and coffee-houses. If they are satisfactory we do not necessarily wish to attract custom from them—we are not out to institute Government competition with existing concerns, but to create new customers from the great mass of workers who have hitherto brought their meals with them, either through choice or necessity. My experience of the cookshops and coffee-houses in the neighbourhood of factories is that they only touch the fringe of the problem, and we certainly cannot look to them to supply the solution. Every canteen is not a success from its commencement; the employees of old-established firms have probably for generations been in the habit of bringing their food with them, and naturally show a reluctance to discontinue this habit. I am glad to say, however, that my experience has shown me that even the most conservative of the workers are gradually becoming appreciative of the benefit of being able to purchase good, freshly-cooked and attractively-served food.

The women, too, are amongst the most enthusiastic users of canteens, and I feel confident that whatever their place will be in industry after the war, those who remain will insist with no uncertain voice on the retention and further development of the canteen movement.

The work in engineering shops demands a high degree of physical efficiency in the workers, and being convinced of the value of canteens in this connection, I am glad to have an opportunity of speaking to this association.

Of the schemes of canteen provision at controlled establishments approved by the Canteen Committee, those in the Lancashire and Cheshire area represent one-seventh of the whole, the seating accommodation being 31,200. This, of course, is exclusive of canteens in national factories and on the docks in this area. Owing to their close connection with the output of munitions of war, engineering firms in general throughout the country show a larger proportion of canteens than any other industry, and I would like to impress upon anyone here present, who has not seriously considered the provision of these feeding facilities, the desirability of so doing. I submit that the proved success of the canteen movement during this time of stress and anxiety has shown that it must continue in times of peace. Although after the war your activities will be diverted and I would like to pay a tribute to the splendid work they have done and are still doing in this connection. As regards employing an outside professional caterer, although this may be quite satisfactory in some instances, yet it is not what I would generally recommend. There can, to my mind, be little question that the canteen should be part of the general works organisation, and be controlled by the firm and its officials. Assuming that it has been decided to run the canteen under the direct control of the firm, the first thing to do is to secure a manager or manageress. It must be remembered that much depends upon his or her personality. The qualifications required are organising ability, power to enforce discipline, a thorough knowledge of buying foodstuffs and a fair working knowledge of cookery. Above all, he or she must be tactful, and imbued with a lively sense of the real meaning of these canteens, the practical expression of the employer's wish to improve the condition of his employees. If this last point is kept in mind it will go far to solve the thousand and one difficulties which may arise. A good way to popularise the canteen is to form a committee of the workpeople to act in an advisory capacity. I do not think I would suggest, save under exceptional circumstances, that the actual control of the canteen should be in the hands of this committee. The general experience is that the workers themselves prefer not to have this control, and it is often

into more beneficent channels, every effort will have to be maintained to secure your supremacy throughout the world, and I contend that canteen provision will not be the least important of your fundamental assets. It is hardly necessary for me to add that the good offices of the Canteen Committee of the Central Control Board (Liquor Traffic)* as the department responsible for advising in regard to canteens in national controlled and uncontrolled factories, as well as for transport workers, will be placed freely at the disposal of any employer desiring to make canteen provision for his employees.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on Friday, November 9, at the Imperial College of Science, Professor C. V. Boys, F.R.S., president, in the chair, the president referred briefly to the great loss which the society had sustained since the last meeting in the death of its treasurer, Mr. W. Duddell, F.R.S.

Mr. R. S. Whipple, of the Cambridge Scientific Instrument Company, said he had known Mr. Duddell since 1898, in which year they had made his first oscillograph. Since then he had been in frequent contact with him, and could conceive of no one with whom it would be a greater pleasure to work. He was a craftsman of the first order himself, and took the greatest pains to assist in the manufacture of his inventions, pointing out the pitfalls, and showing how they were to be overcome. Scientific instrument makers owed him a great debt. He had had the privilege of being associated with him on the Council of the Physical Society for some years. The annual exhibition of apparatus owed its initiation to him, and its success was in large measure due to his energy and persuasive powers. He had also urged the separate publication of the Society's "Proceedings," and had been of inestimable service to it in many ways. His death was a great loss to the society and to science.

A paper "*On the Thermo-Electric Properties of Fused Metals*," by Messrs. C. R. Darling and A. W. Grace, was read by the former.

In a previous paper ("Proceedings," vol. xxix., Part I) the authors described experiments with bismuth, the apparatus then used only being capable of furnishing readings up to 560 deg. C. Methods have now been devised in which the metals examined may be heated in the tube of an electric furnace, and observations made up to the temperature limit of the furnace. The metals experimented with were lead, tin and antimony up to 1,000 deg. C., and zinc and cadmium up to temperatures approaching the boiling point. No change in thermo-electric properties was noticed at fusion, except in the case of antimony, which, like bismuth, shows an abrupt bend in the E.M.F. temperature curve at the melting point, 632 deg. C. This exceptional behaviour of antimony and bismuth is in keeping with the anomalous properties of these metals, both of which expand on solidification; and it is suggested that an allotropic change occurs at fusion in these metals.

In the case of lead which is used as the reference metal in thermo-electric diagrams, it is shown that extrapolation of lines in the diagram beyond 300 deg. led to serious errors, and that although at low temperatures the E.M.F. temperature curves are approximate parabolas, the departure from this shape above 300 deg. is so marked as to render thermo-electric diagrams of little value.

Discussion.—Mr. Whipple said that this work opened up certain possibilities of commercial importance, as it appeared that information could be obtained of the thermo-electric properties which a particular alloy would have while it was still in the molten state. It would thus be possible by adding one or other of the constituents as required to obtain an alloy with any prescribed thermo-electric properties. At present the alloy had to be allowed to cool, and a wire of it drawn and tested. If it were not right, it had to be melted up again and its constitution altered, which was a troublesome method. With regard to the high boiling point and low vapour pressure of tin, it was of interest to observe that Northrup had suggested a tin graphite thermometer for high temperatures up to about 1,700 deg. C. on the same lines as the ordinary mercury in glass thermometers. The tin expanding along the stem of the thermometer moved an index wire by which the temperature was indicated. What was the magnitude of the change in properties of the iron-constantan couple on passing the recalescence point of iron? He was very interested in this point, as he had not noticed any such change himself.

The president said it was a useful thing to have the futility of the old thermo-electric diagram proved so thoroughly.

Dr. Willows suggested that a zinc-mercury amalgam would be an interesting substance to examine thermo-electrically for allotropic change-points. Its resistance curve between 0 deg. and 100 deg. shows marked evidence of such changes.

Mr. Darling, in reply, said he had not detected the recalescence change with the iron-constantan couple probably because of the relatively large total E.M.F. of that couple. The change was easily detected, however, with the iron-tin couple, since the total E.M.F. is then only about three millivolts and a delicate galvanometer is used.

A paper on "*Triple Cemented Telescope Objectives*," by Mr. T. Smith and Miss A. B. Dale, was read by the latter.

The paper describes the four series of triple cemented thin telescope objectives which can be made from two kinds of glass, and determines their construction when first order spherical aberration and coma are eliminated. The second order spherical aberration and coma are then calculated, and the former found to be of the same sign for all optical glasses when the surfaces are spherical. The best standard attainable varies very little over a considerable range of glasses. Diagrams show the variations in the curvatures as the glasses are varied for refractive index and dispersion. Contrary to the general belief, it is found that the objectives with least second order aberrations (absolute values) are not those with the least curvatures for their refracting surfaces.

* The offices of the board are at Latymer House, 134, Piccadilly, London, W. 1.

Society of Glass Technology.—The November meeting was held in the Queen's Hotel, Leeds, on Wednesday, the 21st inst. A large attendance was presided over by Mr. Duncan Webb, of Manchester. After the transaction of formal business, Professor J. W. Cobb, B.Sc., F.I.C., of the University of Leeds, read a paper on "Gas-firing and the Glass Industry."

Triplex Safety Glass.—An important group of New York financial and commercial men have acquired the patent rights for manufacturing "triplex" safety glass for war purposes, including automobile windscreens, ship's portholes, chart tables, bridge-screens, aviation goggles, aeroplane wind-screens and observation panels, and many other important uses. A factory, plant and machinery are in course of construction for the manufacture of "triplex" glass in America, and will shortly be in operation. Meanwhile a member of the syndicate, Mr. W. J. Finlay, is in London, and will deal with all inquiries.

New South Wales Notes.—The latest mail advices from Sydney indicate that the strike is over. The New South Wales Government is working 15 collieries which should to-day be raising 7,000 tons per day; in the middle of September there was a reserve stock of 200,000 tons of coal. The majority of the mines are being worked at a fixed price per ton, the Government paying the cost of railway fares and the camp expenses of the loyal volunteers. Encamped at the Sydney Cricket Ground and Taronga Park are 6,000 country volunteers, who practically monopolise the wharf labour. A new union of waterside workers has been formed, having as a basis a minimum weekly wage, instead of payment by the hour as at present. Up to the end of September applications for new registration were received from eight newly organised unions by the New South Wales Government.

New Zealand Railways.—H.M. Trade Commissioner in New Zealand (Mr. R. W. Dalton) reports that, according to a recent issue of the *New Zealand Herald*, a new type of locomotive has been employed on the Woodville–Taihape section of the Main Trunk Railway of the Dominion during the past three months. The first of the class was constructed at the Government workshops at Dunedin for service on the Canterbury Plains some two years ago. When tried over the level country between Christchurch and Oamaru, the new engine gave such excellent results that it was decided to try it over the sharply-graded section between Oamaru and Dunedin, and there again it satisfied all tests. Four of the new engines were sent to the North Island some months ago and have been employed on the Wellington–Taihape section with good results. It appears that this engine can travel further than the compound engine without taking in water, and that it has a greater hauling capacity. Mr. Dalton adds that it is the policy of the New Zealand Government to construct in the Dominion as many as possible of the engines it requires, but, while this is so, he thinks that United Kingdom firms may be interested in the above information, which he has supplemented by forwarding three outline diagrams of the new type of locomotive. These diagrams may be inspected at the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2.

Association of Engineering and Shipbuilding Draughtsmen.—The second annual general business meeting of the Hartlepools Section (Tees-side and Hartlepools Branch) of the Association of Engineering and Shipbuilding Draughtsmen was held in Birks' Café, West Hartlepool, 80 draughtsmen, representing every engineering and shipbuilding firm in the district, were present. In his opening remarks, the president said it was gratifying that the membership of the Association had risen from 300 in 1915 to 8,000, and was still advancing rapidly. In submitting the annual report, the secretary stated the membership of the branch was 110, representative of all the engineering and shipbuilding firms in the district. It was gratifying that during the present year, branches had been established at Middlesbrough and Stockton, with corresponding members in the outlying districts, so that the total membership for the district was 340, while the membership of the association was well over 8,000, with 52 branches established throughout the United Kingdom. The energies of the association, apart from propaganda work had been devoted to various questions affecting the welfare of draughtsmen, viz., exemption cards, war bonuses, leaving certificates, Munitions of War Acts, &c. Recently, through the energetic efforts of the association, draughtsmen on "time rates" have participated in the 12½ per cent. award to skilled workers, whilst the Ministry of Munitions is prepared to consider an advance to all draughtsmen in receipt of emoluments not exceeding 250*l.* per annum, provided they are not in receipt of a bonus on output, and proposals which have been agreed to between employers and employees with regard to this should be submitted to the Minister for his consideration.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The position has not improved much on the week so far as the buyers are concerned, for supplies are coming to hand very slowly, and the opportunities of obtaining free lots on the open market are more restricted than ever. A fairly large tonnage is passing for the Admiralty, War Office and Allied Powers, whilst the home demand keeps collieries very busy with contract requirements. Works manage to get enough for daily running, but are not able to set anything aside for stocking purposes. Best steam hards are most eagerly sought, but there is no surplus on the market. Gas fuels are going away in large quantities to inland works on account of contracts, and the efforts of the companies to get an additional tonnage does not seem to meet with much success. Slacks are tight and supplies are hard to get. Cokes remain strong at top prices. The house-coal position is still one of considerable anxiety, for the inquiries are far in excess of the capacity of dealers and merchants to cope with them. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; and smalls, 9*s.* to 10*s.*, per ton at the pit.

Iron and Steel.—The chief interest in the position to-day is still centred around the question of whether the advance will materialise in common irons. The general feeling is that an announcement must be expected at an early date, and the point of doubt is the size of the award. In the meantime, buying proceeds at a much more even pace than was the case a week or so ago. Consumers are wanting to build up stocks again, and in all cases makers are able to get the limit price, and the conditional undertaking in the case of running contracts regarding any new advance, without difficulty. The supply of basic iron continues to expand, and is meeting the increasing consumption of steel makers. The furnace which has recently been lighted at Renishaw has been placed to basic, and makes a welcome addition to the local supply. The steel output is progressive. High-speed steel makers are concerned with a level lot of indents which continue month after month without fluctuating, but in the other cases, both in aircraft and marine work, the specifications mount up with remarkable rapidity. More furnaces are being placed to aeroplane constructional steel, and the increased output is helping to meet an excessively big demand. Satisfaction is also felt at the output of open-hearth steel, which is regarded as having reached figures previously untouched. File-makers have nothing in hand for Russia, but find other orders sufficient to keep them busy. Agricultural engineers have now received substantial indents for complicated forms of farm machines for the spring work, but do not expect to repeat the last boom in the smaller and simpler implements largely used by allotment holders. Cutlery and plate firms are concentrating on export trade, orders for which are plentiful.

New Swedish Shipyard.—The new shipyard at Norrköping is now approaching completion, and shipbuilding operations have already commenced. The concern has been taken over by a newly-formed company, Ostersjövarvet, the Baltic Shipyard, with a minimum of 851,000 kroner and a maximum capital of 2,550,000 kroner. The yard is in a favourable position, and the site purchased has already had to be extended. The slips which adjoin the harbour basin are built so that they can be lengthened in order to accommodate vessels up to 5,000 tons, but the first keel laid is only for a vessel of 750 tons, which is expected to be ready by February next year. At present both wood and steel are used for building material, but the object is to build steel vessels only, when this material can be obtained. A capacious floating dock will be constructed and the slips will partly be covered in.

Large Zinc Crystals.—The publication of the experiment by Messrs. Julius Pintsch on the production of tungsten wire, consisting of very long crystals (ENGINEERING, page 232 *ante*), has induced Dr. W. Fraenkel to describe some experiments of his on large zinc crystals (*Zeitschrift für Elektrochemie*, October, 1917). It is well known that zinc, when poured hot and cooled slowly, may give a sheet metal in which large crystals can be distinguished. By the subsequent rolling and drawing the structure is made finely crystalline, and the strength of the metal is increased. Such zinc retains a tendency to recrystallising again, however. In buildings which had been destroyed by fire in Martinique in 1903 Lacroix found some zinc bars consisting entirely of one crystal. Fraenkel examined a zinc wire, which had broken when drawn to a diameter of 13 mm., and displayed a very coarse structure. Attempts to imitate that structure failed until he heated the drawn wires almost up to their melting point. Even then success was only obtained in a few cases. Of a batch of nine wires heated in one experiment in an electric furnace, one showed that the whole section of the wire consisted of one crystal only; the fracture was not right across, but seemed to follow an oblique cleavage face. This wire had a diameter of 10 mm. Another example of 8 mm. showed two crystals, whilst in most of the other cases the structure was irregular, but essentially finely crystalline. Reheated and redrawn, these special wires displayed the same peculiarity. Some undetermined factor, therefore, appears to be at play.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade. — The intense activity in the steelmaking industry, continues unabated. No falling-off in the supply of munitions can be contemplated, therefore all available effort is concentrated upon the production of high tensile bars, as well as of the ship-building material—plates, sections, &c.—required in the construction of the standardised vessels ordered and approved by the Shipping Controller. Beyond this, considerable anxiety exists in the minds of both makers and consumers as to what steps will be taken by Government in connection with the advance in prices rendered necessary by the increased cost of fuel. The uncertainty regarding this matter is not advantageous to trade, and is keeping many prospective orders hanging in the balance, as definite quotations are difficult to give or obtain. Every rolling mill is busy, and, with the New Year holiday settled and in sight, it is expected that further developments may take place when the machinery and plant are overhauled during the workers' absence. Little export is being put through meantime, nothing beyond some small shipments to France and Italy, but for these the rates are decidedly firm.

Malleable Iron Trade.—There is no cessation of activity in the malleable iron trade, makers being fully booked up with orders which will keep them busily employed for many months to come. The bulk of this work, naturally, is required on Government account for national purposes, mainly, of course, war material. Home prices continue on the level of last week, but for export, rates have firmed up, and some "fancy" prices are being quoted and accepted.

Scotch Pig-Iron Trade.—At the moment the pig-iron trade seems to be in a kind of transition stage, the dubiety as to the ultimate fixing of prices having a most unsettling effect, the decision that the advance is to be made retrospective as from September 17 in no way clearing the ground. All brands of pig-iron are in urgent demand, hematite, as usual, heading the list. The scarcity of certain brands grows daily, No. 3 foundry iron particularly so. While export is decidedly slack, a rapid advance in price on consignments going overseas has taken place, in some instances as much as 10*s.* per ton and upwards, of course, only where rates were not controlled.

Shipyard Extension.—An engineering deal of some considerable importance has just been announced, the taking over of the engineering business of Messrs. David Rowan and Co., Elliot-street, Glasgow, by Messrs. Russell and Co., shipbuilders, Port Glasgow. For many years now Messrs. Russell and Co. have enjoyed the distinction of turning out the largest gross tonnage of new shipping on the Clyde, their speciality being cargo steamers of, practically, standardised types. The present is the third establishment they have taken over within the past few years, but neither in their own yard nor in the two previously-acquired were there facilities for marine engineering, the machinery for the ships constructed by them having always to be obtained elsewhere. This difficulty will now be overcome, for Messrs. Rowan and Co. have specialised in the construction of engines for cargo steamers for some considerable time past, in consequence of which the premises in Elliot-street are particularly well equipped for dealing with this class of work in the minutest details, and many of Messrs. Russell and Co.'s vessels have been engined here.

SPONTANEOUS EXTINCTION OF FLAMES IN ENCLOSED VOLUMES OF AIR.—The question is sometimes asked how long the flame of a candle or other flames would continue to burn within an enclosure, the oxygen of which the flame would gradually consume. Experimenting on this problem Friedrich G. Müller (*Zeitschrift für den physikalisch-chemischen Unterricht*, vol. xxx, pages 28 to 30) finds that the air in which a candle finally became self-extinguished would still contain from 13 per cent. to 15 per cent. of oxygen, whilst the carbon dioxide percentage would have risen to 6 per cent.; this composition strongly resembles that of deeply-expired air. Alcohol burning on cotton wool similarly leaves an air containing from about 11 per cent. of oxygen and 16.5 per cent. of CO_2. Glowing charcoal is less liable to extinction; it left only 9 per cent. of oxygen and 8 per cent. of CO_2 in the air; burning sulphur on the other hand, is more easily extinguished; it goes out when the oxygen percentage falls below 13.5. The persistency of the charcoal glow is noteworthy.

THE LATE PROFESSOR A. W. THOMSON.—The death occurred on Tuesday, the 27th inst. in Glasgow, of Mr. A. W. Thomson, a native of that city who held important engineering appointments in Japan and India. Dr. Thomson was born in 1851, and was educated in the Neilson School, Paisley. He was a distinguished student of Glasgow University, where he attended the engineering classes under Professor Macquorn Rankine. He studied also under Lord Kelvin, and graduated B.Sc. in 1874. In 1878 he became assistant professor in the Engineering College, Tokio, a position which he held till 1881, and in the following year was appointed Professor of Engineering in the Agricultural College, Cirencester. Remaining there for five years, he subsequently went to India and took up the position of Professor of Engineering in the College of Engineering of the Government of India, Poona, in 1890. He occupied that office for 19 years. Professor Thomson took the degree of Doctor of Science in Engineering at Glasgow University in 1901. He made some contributions to the literature of engineering, and was associated in this connection with Professor Alexander of Tokio.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Continued delay in the announcement of any decision concerning readjustment of pig-iron prices, or rectifying the position brought about by the increased cost of production in some other way, elicits strong expressions of dissatisfaction, and traders declare that the resulting uncertainty is very prejudicial to business. The opinion is growing that sanction to advance fixed maximum quotation will not be granted, but that the position will be adjusted by subsidising manufacturers. Resumption of home activity in Cleveland pig-iron is noticeable with the commencement of issue of December allocations. November distributions have fallen very considerably below expectations, due chiefly to the shortage of trucks, and the result is that applications for allotments over the last month of the year are exceptionally heavy. It is hoped that December deliveries will be on a fairly good scale. The export department is still quiet, but there is a little more business passing. Rather more tonnage is coming forward. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge, all stand at 89*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; whilst for shipment to the Allies, No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant market still stands at 608 tons, all of which is No. 3 quality, no change having been recorded since the 7th inst.

Hematite Iron.—The East Coast hematite branch shows little or no change. Under strict official supervision home deliveries are maintained on a scale sufficient to meet minimum needs, but very little surplus iron is available for export. Mixed Nos. are 122*s.* 6*d.* for home use, and 141*s.* for export to the Allies.

Coke.—The heavy demand for coke for local use continues to be met by very ample supply, with the result that the market is active. Average blast-furnace kinds are 33*s.* at the ovens, and low phosphorus sorts 35*s.* 3*d.* at the ovens.

Manufactured Iron and Steel.—In the finished iron and steel industries pressure for delivery to meet the huge Government requirements, and the heavy needs of the shipyards is unabated, and with such demands absorbing practically the whole of the output, traders realise that it is almost useless attempting to put through ordinary commercial business. Prices are very stiff. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.* 10*s.*; packing iron and steel (parallel), 13*l.* 10*s.*; packing iron and steel (tapered), 15*l.* 15*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; and heavy steel rails, 10*l.* 17*s.* 6*d.*

Messrs. Dorman, Long's Latest Acquisition.—Following their present commitment to a capital expenditure of 2,000,000*l.* in the erection of enormous steel plant at Warrenby, near Redcar, the Middlesbrough firm of Messrs. Dorman, Long and Co., Limited, have purchased for, it is currently reported, 1,500,000*l.*, the whole of the undertakings in the Tees-side district of Messrs. Sir B. Samuelson and Co., Limited, comprising their Newport Ironworks at Middlesbrough, consisting of eight blast-furnaces, large modern coke-oven plant, &c., collieries and ironstone mines. It is interesting to note that the whole of the Middlesbrough municipal gas supply is obtained from the installation of coke ovens at Messrs. Samuelson's Middlesbrough works. Mr. A. J. Dorman, the head and one of the founders of the huge industrial concern of Messrs. Dorman, Long and Co., Limited, has been mainly responsible, by his great business acumen and indomitable energy, in transforming a moribund business into one of the most prosperous concerns in the North of England. When industrial prospects in the North-East iron centre were anything but bright, Mr. A. J. Dorman, in conjunction with the late Mr. de Land Long, acquired the West Marsh Ironworks, Middlesbrough, and by adopting new and improved methods of manufacture succeeded in creating a demand throughout the world for their products. The fine Dorman Museum at Middlesbrough was a gift to the corporation by Mr. Dorman, and the now gradually growing garden city of Dormanville, where some 160 houses have already been erected near the firm's new undertakings at Warrenby, is watched with the greatest interest by the head of the firm of Messrs. Dorman, Long.

THE BETHLEHEM SHIPBUILDING CORPORATION.—What will be known as the Bethlehem Shipbuilding Corporation, Limited, says *The Marine Journal*, New York, will be the result of a merger which is now being effected of all the shipyards, namely, the Fore River Shipbuilding Corporation, Quincy, Mass.; Union Iron Works Company and Union Iron Works Dry Docks Company, San Francisco; Harlan and Hollingsworth Corporation, Wilmington, Del.; Samuel L. Moore and Sons' Corporation, Elisabeth, N.J.; and the Shipyard at Sparrow's Point, Md., controlled by the Bethlehem Steel Corporation. The capitalisation will be 12,500,000 dols. This combine is for the purpose of centralising management and increasing production to meet the demands of the times. No radical change will be made for the present in the operating methods of all these plants, with the exception that sales, purchases, &c., will all be made at Bethlehem hereafter.

THE FEDERATED MALAY STATES.

FROM the report of the acting general manager, we learn that the working of the Federated Malay States Railways during the past year produced a net profit of 4,027,228 dols. (469,843*l.*), compared with 2,636,397 dols. (307,579*l.*) in 1915. This result affords a striking commentary upon the general prosperity of the Malay Peninsula, and the fact that a very large proportion of the increase in gross receipts occurs in passenger traffic tends to show that the native population are occupying a remarkably sound financial position, due doubtless to the maintenance of good prices for tin and rubber and to the development of the latter industry. The total number of passengers carried in 1916 was 14,741,066, as compared with 11,899,028 in 1915. Of these, 12,229,939, or 82.96 per cent., were third-class passengers.

Receipts from all sources amounted to 1,355,114*l.*, an increase of 299,302*l.*, or 28.34 per cent. Of this increase, no less than 194,781*l.* arises on passenger traffic. The expenditure amounted to 885,437*l.*, an increase of 137,039*l.*, or 18.30 per cent. This increase is attributable almost entirely to the very high cost of stores and materials, particularly coal. In the running of locomotives alone this one item is responsible for additional expenditure of about 80,500*l.* In considering this point, it must be borne in mind that the total volume of materials purchased would have been considerably greater had it been possible to obtain them, even at enhanced prices, and the railway has been working under a considerable handicap owing to the shortage of supplies. The net profit for the year is equivalent to a return of 3.94 per cent. on the total capital expenditure (including lines not open for traffic), or to 4.35 per cent. on expenditure on open lines only.

The total capital expenditure to December 31 last is 11,924,732*l.* Capital expenditure during the year amounted to 373,577*l.*, out of which 207,638*l.* was spent on lines not open for traffic. There has been a good deal of new construction work during the past year, notwithstanding the difficulty of obtaining steelwork from England, by far the most important work in point of railway policy as well as expenditure, being the extension of the East Coast Railway in Pahang and the extension on the West Coast through Kedah and Perlis to connect the Federated Malay States system with the Siamese system at the northern frontier. During the present year this latter section has been still farther advanced, and a party of Federated Malay States and Siamese officials has made the complete overland journey from Bangkok, the Siamese capital, to Kuala Lumpur, the capital of the Federated Malay States. As soon as the necessary steelwork for the unfinished bridges is obtainable, traffic will be opened up between Penang and Bangkok, and an important chapter will be added to the railway history of Eastern Asia.

It is possible from the statistical information appended to the report to make the following interesting comparison between last year and the year preceding the outbreak of war:—

	1913.	1916.
Miles open to traffic	771	1,028
Stations	174	211
Engines	153	195
Passenger coaches ...	298	413
Other coaching vehicles	65	135
Goods vehicles	3,289	3,761
Service vehicles ...	—	947
Train mileage	3,351,045	3,829,274
Passengers carried ...	13,143,659	14,241,066

The total goods tonnage carried was 1,267,031 tons, compared with 1,100,381 tons in 1915, while the total number of live-stock was 122,427, compared with 104,822.

During the year, 79 ocean steamers called at Port Swettenham with import cargo and 39 for export cargo, exclusive of the regular British India steamers running between Singapore and India. Rubber to the extent of 28,932 tons was exported through this port, against 22,172 tons in 1915 and 15,147 tons in 1914.

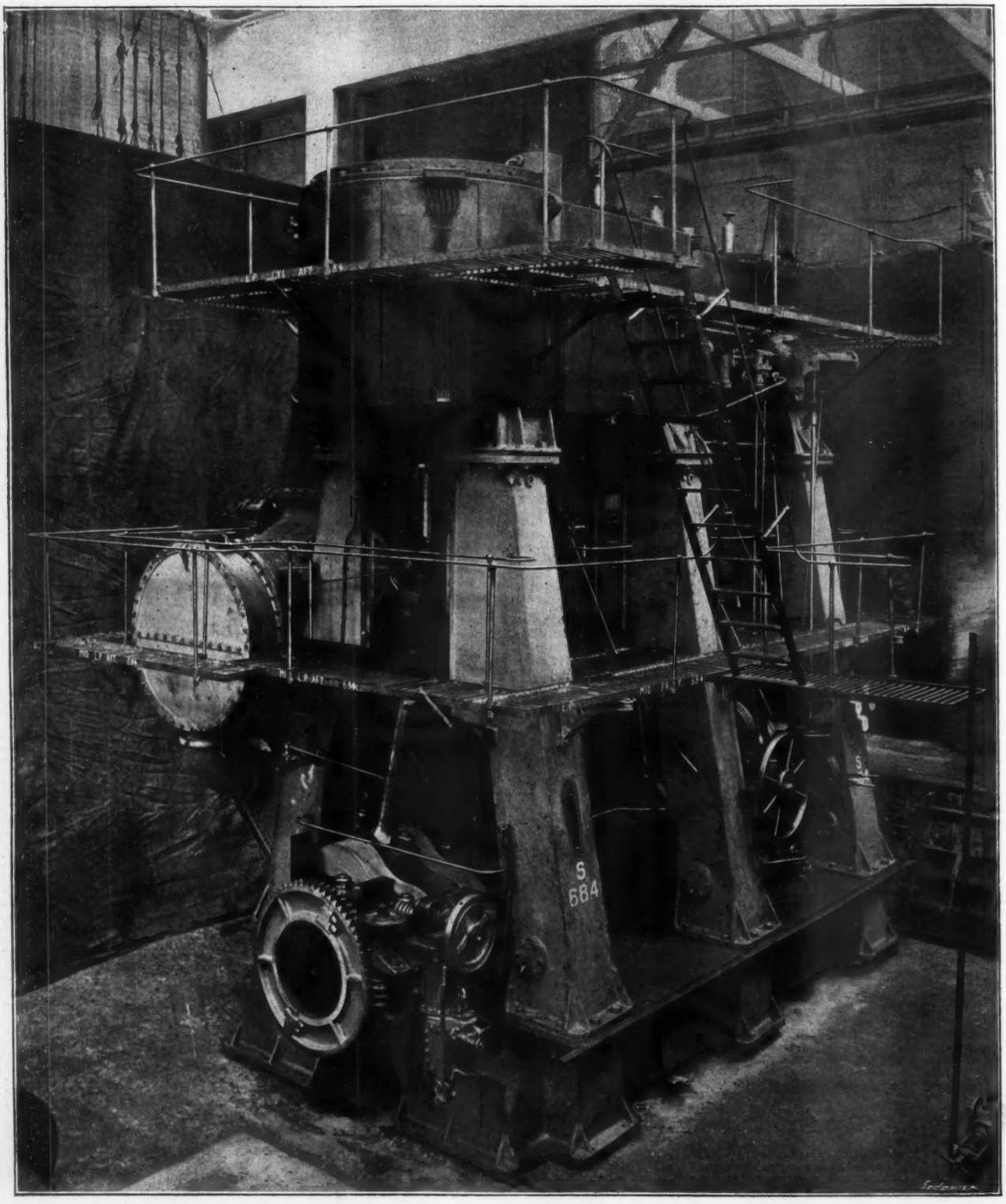
Not the least interesting portion of the report to manufacturers in this country is that dealing with the stores and materials obtained through the Crown Agents for the Colonies. Out of a total of 148,845*l.*, the sum of 107,724*l.* was paid out through the Crown Agents, compared with 240,826*l.* in 1915, the decrease doubtless being due to the difficulty of getting supplies from England. A further sum of 26,405*l.* was spent upon construction stores obtained through the Crown Agents, out of a total of 89,943*l.*

Throughout the year, Mr. P. A. Anthony, general manager, was engaged on special duty in London with the Ministry of Munitions, and 18 members of the European staff are on active service with His Majesty's forces.

CHANGES OF CRYSTAL ANGLES BY CHANGES OF TEMPERATURE.—Resuming his experiments on the changes produced in the angles of crystals by their being slowly heated or cooled through considerable ranges of temperature, F. Rinne observed, in the case of Iceland spar, a change in the angle of the rhomboid (about 75 deg.) by more than 1 deg., when the temperature was raised from − 170 deg. to + 560 deg. C. The mean change per 100 deg. C. was 9.1 minutes of arc, and the angle became larger on heating. Experiments with dolomite gave the smaller rate of change of 4.8 minutes per 100 deg., with apathic iron from Cornwall a change of 3.1 minutes. All these changes were fairly regular. Similar results were recently obtained with crystals of other systems, augite, hornblende and diopside.

STANDARD TRIPLE-EXPANSION ENGINES FOR BRITISH STANDARD MERCHANT SHIPS.

(*For Description, see Page 569.*)



STANDARD TRIPLE-EXPANSION ENGINES

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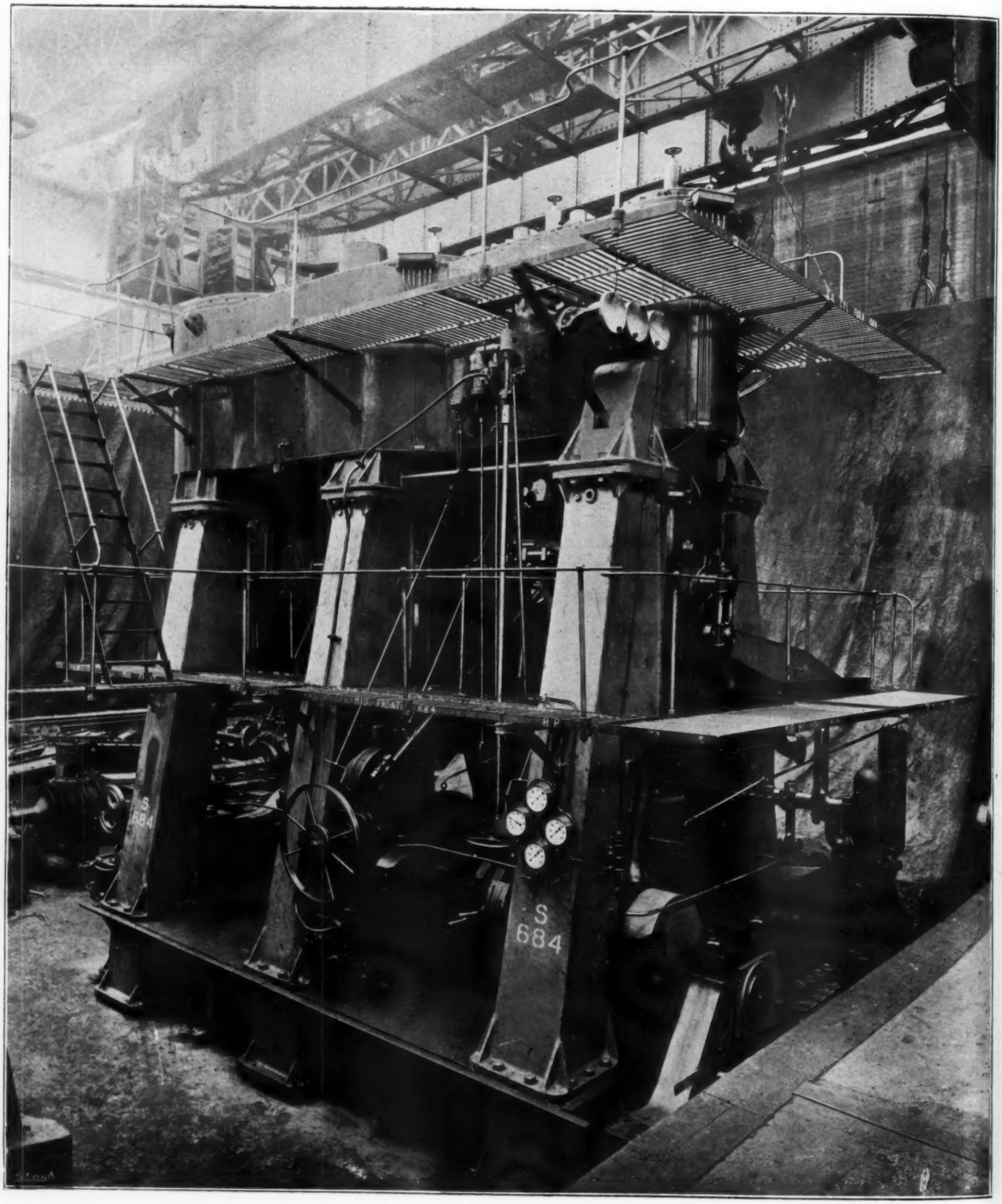
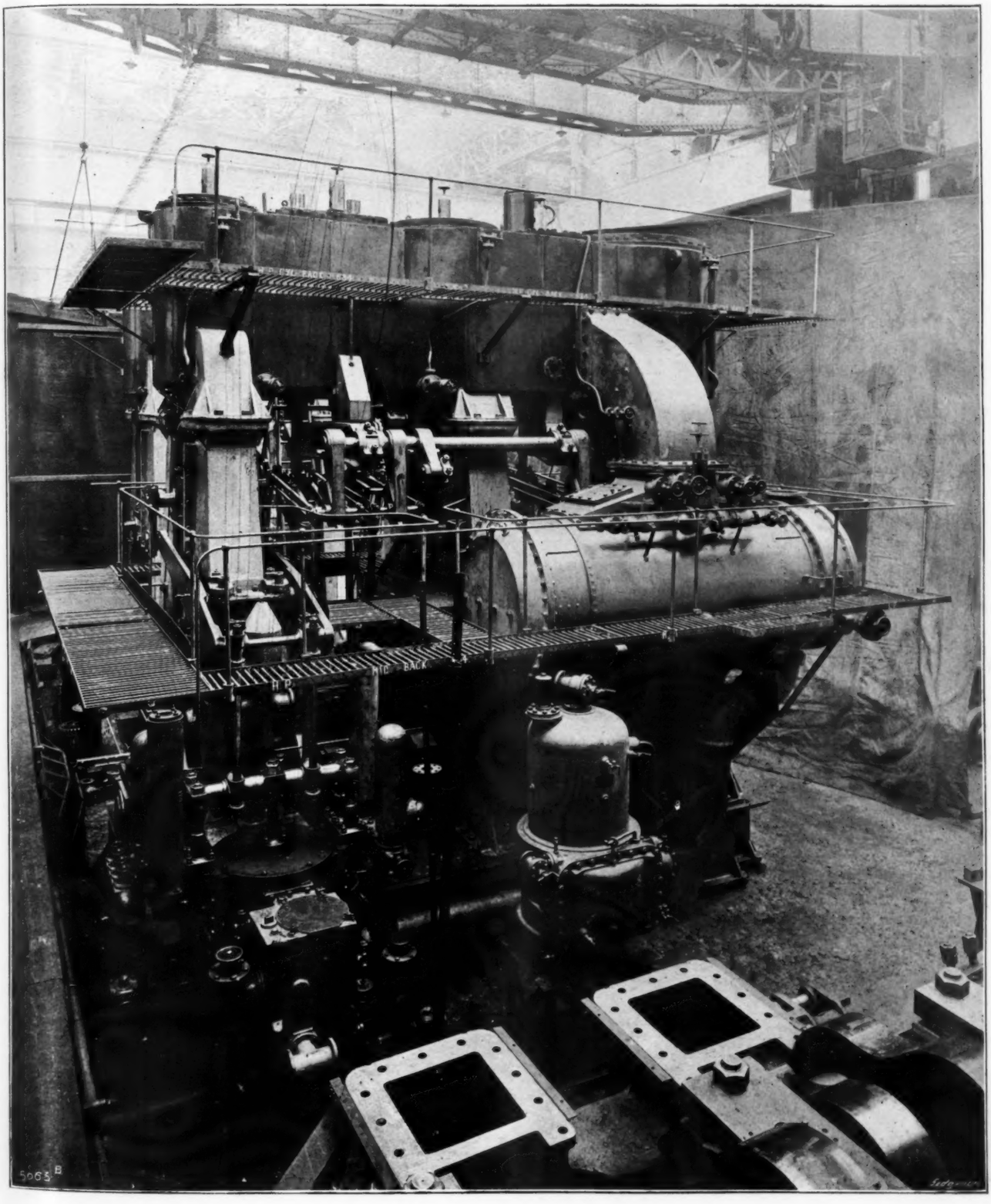


BRITISH STANDARD MERCHANT SHIPS.

(Page 569.)



AGENTS FOR "ENGINEERING."

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"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 4 6
For Canada—	
Thin paper copies	£2 0 6
Thick ,, ,,	£2 5 0
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Thin paper copies	£2 5 0
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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS: "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 30, at 6 p.m., at the Institution of Civil Engineers. The Thomas Hawksley Lecture, "Heat Engines," will be delivered by Captain H. Riall Sankey, C.B.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, November 30, at 7 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate Road, Newcastle-on-Tyne. Annual general meeting, with Inaugural Address by the President.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 30, at 8 p.m., at 39, Victoria Street, S.W. 1. "Drawing Office in Relation to other Departments," by Mr. R. D. Roberts.

THE LONDON ASSOCIATION OF FOREMEN ENGINEERS.—Saturday, December 1, at 7 p.m., at Cannon Street Hotel, London, E.C. Annual meeting and election of officers.

THE ROYAL SOCIETY OF ARTS.—Monday, December 3, at 4.30 p.m. Cantor Lecture.—"Progress in the Metallurgy of Copper," by Mr. H. C. H. Carpenter, M.A., Ph.D., Mem.Inst. M.M., A.R.S.M., Professor of Metallurgy, Imperial College of Science and Technology (Lecture I). Wednesday, December 5, at 4.30 p.m. Inaugural "Trueman Wood" Lecture.—"Discovery and Invention," by Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. Mr. Alan A. Campbell Swinton, F.R.S., Vice-President and Chairman of the Council of the Society, will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 4, at 5.30 p.m. Paper to be submitted for discussion:—"Recent Developments in By-Product Coking," by Mr. George Blake Walker, M.Inst.C.E. Ballot for new members.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 5, at 7 p.m., at the University, Edmund Street, Birmingham. Mr. T. M. Hunter, M.A., B.Sc., will read his paper entitled "Gas-Firing Boilers."

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, December 5, at 2.30 p.m., at the Midland Grand Hotel, St. Pancras. The further discussion of Mr. R. S. Griffiths's paper, "Some Impressions of Continental Signalling Practice."

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, December 6, at 3 p.m., at the University, St. George's Square, Sheffield. The following paper will be read:—"University Education in Relation to Mining Engineering," by Mr. W. Ripper, D.Sc., F.R.S., Vice-Chancellor of the Sheffield University. The following papers will be open for discussion:—"On the Splitting of Coal Seams by Dirt Partings," Part I.—"Splits that Rejoin," by Professor F. F. Kendall, M.Sc., F.G.S., Leeds. "Areas of Deposition of the Coalfields of North-Western Europe," by Mr. G. Blake Walker.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 6, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster, S.W. "Electrical Cooking as Applied to Large Kitchens," by Mr. W. A. Gillott, A.M.

THE INSTITUTION OF WATER ENGINEERS.—Friday, December 7, at 2.15 p.m., in the apartments of the Geological Society, Burlington House, W. A discussion on "Water Supplies as Sources of Power," will be opened by Mr. Cecil H. Roberts, M.Inst.C.E., and papers will be read on (a) "Theory of the Air-Lift Pump," by Mr. Charles Anthony, M.Inst.C.E., and (b) on "Theory and Practice in Air-Lift Pumping," by Professor A. H. Jameson, M.Sc.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, NOVEMBER 30, 1917.

ECONOMICS OF PERSONAL LABOUR.

PROFESSOR MOSSO, of Turin, in his classic examination of "Fatigue," remarks that during the past centuries every nation has been dominated by one fixed idea—"how to render more effective the work of brain and hand." While this generalisation may be easily justified and copiously illustrated, there arises the question as to the extent to which the idea has borne fruit in actual achievement, and in the knowledge of the scientific principles involved. Baron Dupin, a distinguished engineer and educationist, when advocating a liberal and technical training for French operatives, pointed out in 1829 how little care had been given to the human machine—"a machine," as he said, "of the first order, self-starting, self-attending, self-correcting, self-stopping, moving under an intelligence residing in it and capable of being improved by work and thought." Assuredly, he urged, there is much to be gained from perfecting to the utmost that wonderful mechanism, and from acquiring such control over its operations as will make for increased efficiency. Now Dupin's way of looking at the human machine although uncommon, had little of novelty. De la Hire in the seventeenth century, the Bernouillis and Euler somewhat later, interested themselves with investigations on maximum man-work under varying conditions, and Coulomb's essay in 1783 on "Human Forces" is even now a valuable contribution to the subject.

While, then, the philosophers all along have given serious study to the nature and economics of personal labour, the practical people have stumbled forward, feeling their way, more or less consciously, towards the ends indicated by the advocates of scientific method. Of late, however, the phrase "organisation of personal labour" has assumed special importance and aroused the attention of employers. The views of the theorists have hit the minds of directors and works managers to whom measurable economies in the use of an operative's available energy are now at once possible and imperative. To the American *entrepreneur* F. W. Taylor is largely due this rapid diffusion of the gospel of method in human work. How simple his dictum—all movements needed in an operation, to be performed in minimum time, and all others to be cut out. Capable workmen, under keen but not obtrusive observation, clever chronometer readings and skilful analyses make the solution of problems of improved methods an easy matter.

As showing the widespread influence of Taylor's "scientific management" take the following sentence from a contemporary writer. "He concentrated himself upon his work and how to save time, pointing out to Martin where he did in five motions, what could be done in three. 'Elimination of waste motion' Martin phrased it, as he watched and patterned after." The writer was Jack London, and the work that of a laundry. But let it be added that the author, inconsequentially perhaps, found it necessary to make his admirable exponent of laundry work go "badly on the booze" at week ends. So it comes about that Jack London's finding may help to illumine Sir Robert Hadfield's foreword to Professor Spooner's excellent pamphlet on "Industrial Fatigue as Related to Maximum Output." Thus speaks Sir Robert "Whilst I believe in the argument of a proper day's work for a proper day's pay, and in the adoption of improved methods that eliminate unnecessary fatigue, I am strongly opposed to any attempts being made in the direction of driving the workers." The same finding has also some bearing on the statement of Mr. J. R. Clynes, M.P., that "the workman does not look with favour upon methods designed scientifically to speed him up, in order that, without making him either a more skilled workman or a more contented human being he should be a more effective producer of marketable goods," although, what Mr. Clynes means by "a more skilled workman" may not be any clearer than Sir Robert Hadfield's "proper day's work." Each of these three references fails, in that inadequate regard is paid to even our standard definition of fatigue. That definition was lately presented to Parliament by Professor Kent, and is to the effect that "Fatigue indicates a state of diminished efficiency occurring after labour and partly dependent on it, the degree of fatigue being determined partly by the duration and character of the labour performed and partly by a variety of other circumstances."

In view of the urgent importance of the subject before us and our imperfectly defined knowledge of fatigue, we have pleasure in calling attention to Dr. Amar's lately published book on the organisation of personal labour from the standpoint of physiology. It is suggestive that shortly after Mr. Taylor's visit to France in 1912 with the object of expounding the scientific principles of workshop management, Dr. Amar was made Professor of the Physiology of Work by the Minister of Labour. Taylor had maintained that physiologists and engineers alike had contributed little to the knowledge of "human endurance" and the economics of personal labour. The scientific work on which Amar had been engaged found now a very practical objective and filled the gap. Taylor's system, with its analysis of the time and movement elements in operations, and its selection of methods, after meticulous observations, had worked wonders. Still there was a loss of elasticity and a possible approach

to the danger point of exhaustion of nerve and even muscle elements, and Amar, while admitting that Taylor had a fine instinct and did not blunder in pushing his system unwisely, proceeded to attack the subject with the quantitative appliances and scientific methods of the physiological laboratory. Further, the question with him was not one relating to the wages and profits of production, but rather to the safeguarding of human life and the welfare of future generations. Accordingly the great book to which we have just referred aims at giving instruction in the laws of active life so that waste and disaster may be escaped. The war has emphasised that aim, and it may be said of Dr. Amar that there are few men who have turned their science and genius to such splendid account as he has done in the cause of limbless and disabled soldiers. The professor desires to lend a helping hand, after the war, in the organisation of Labour on rational (shall we say physiological ?) lines, and we may venture to prophesy that the investigations Dr. Amar has made and the anthropometry processes he employs, apart altogether from the long series of ingenious and most useful appliances he has devised, will prove invaluable in the rebuilding of industries in France.

The reader of the book soon discovers its self-contained character. The whole field is covered, yet all essential details are presented in the lucid, accurate and orderly manner of a skilful teacher. The framework of the human body; the muscle, nerve and blood systems; respiration, nutrition and energy transformation are all adequately discussed and illustrated. The chain of events from surface stimuli to response, reflex or deliberate, is stated without periphrastic dogma. Consciousness is a "synthesis of sensations, regularising, ordering and adjusting." Even the law of functional hegemony gets nothing more than that "every organ capable of contracting or sharing in any exercise may be the seat of more intense nutritive and respiratory changes than any other." Simple, clear statements of fact and sufficient for us. Dr. Amar accepts the scheme of cerebral localisations of function, and, without committing himself to Brodmann's psychical activity area, admits the importance of the neurones of the grey sheet covering the lower part of the frontal lobe, in the growth and exercise of Will. The measurement of reaction times (the personal equation) is fully described, and wise suggestions are made as to the bearing of these measurements on settling lines of work—a most important consideration in the case of those maimed soldiers who cannot return to their pre-war occupations.

In the psycho-physical sections, particularly those treating of pleasure and grief, Dr. Amar gives prominence to phenomena disregarded by Mr. Taylor, yet of extreme importance in dealing with the organisation of human labour. These emotions he affirms (and who can doubt his finding ?) modify the neuro-muscular energies—not, of course, as direct contributors or as users-up of energy, but from their interference with the normal course of the nutrient and circulatory functions. Joy and pleasure raise the tone of the voluntary muscles and incline them to work, whereas grief inhibits muscular innervation, disturbs breathing, diminishes amplitude of heart beats and gives peripheral vaso-constriction. In face of these phenomena, does it not follow that to have labour efficient, the attitude of mind of the employer should favour those vital operations on which energy transformations depend ? Therefore, however true it is that the educated will may control emotions and their physiological consequences, it cannot be assumed that such control is so common as to justify our disregarding the feelings of employees even should the power of "striking" work be neglected.

We have thought it well at this time to lay emphasis on the spirit which pervades Dr. Amar's pages and the broad scientific basis on which his thesis rests, as offering a contrast to the methods and aims of the American expositions of scientific management of the worker's energy. It would, however, be entirely wrong to assume that the illustrious French surgeon is not a practical man. Almost 300 pages of his treatise are taken up entirely with purely practical methods of measuring, controlling and economically using human labour. Dynamographs, tambours and registering cylinders are called into play to measure the pressures exerted and the resistances overcome in a variety of such manual operations as, *e.g.*, planing, filing, digging and transporting. As respiratory changes afford reliable information of the total muscular efforts put forth, we are shown how the oxygen consumption is accurately determined, and the ways in which heart-beats and blood pressures are examined and graphically represented. The theory of fatigue as an intoxication is confirmed experimentally, and the conditions of reinvigoration during rest periods are tested in the laboratory. From the demonstration of the influences which toxic products of over-exercise have on nerve terminals of muscles, joints, bowels, &c., we are led to conclude that it is inadvisable to attempt "the refreshing of the spirit by fatiguing the body."

Dr. Amar's contribution to the science of personal labour consists not so much in his finding out, by observing and comparing the movements and postures of operatives, what changes or eliminations promise an increase in efficiency, as in his bringing the whole phenomena of effort under the quantitative tests of the laboratory, and his demonstrations of the physiology and chemistry of fatigue whether due to the duration or the severity of the work, or to the conditions under which it is carried on.

To orthopædic hospitals, where earnest endeavours are being made to mitigate war-created disabilities, Dr. Amar's statement of principles and description of processes are invaluable. Among the many things which have sprung from his analytical and fertile mind the "working-arm" with its clever control by chest movements elicits admiration, and the success with which the possibility of directed arm action and effective grasp of fingers has been given to armless men is a fine testimony to Dr. Amar's quality as physiologist and mechanician. The results obtained from the employment of his appliances and methods afford most helpful guidance to those who are instilling the technique of new trades to disabled soldiers, while his dynamometers give ready information of the curative changes that may be induced by the new exercises. Incidentally and doubtless in view of achievements in trade-training schools for injured soldiers, Dr. Amar deplores the unsatisfactory nature of ordinary apprenticeship training.

The whole drift of Dr. Amar's book* is towards order and harmony in the activities of the individual working in a social system where each will do the work he can do best and in the best way, with no unnecessary expenditure of energy, no permanently baneful fatigue, but with due regard to the economics of his labour and personal satisfaction in the doing.

* "Organization Physiologique du Travail," by Dr. Jules Amar. Published by H. Dunod and E. Pinet, Paris. [Price 18 francs.]

NITRATES IN WAR AND PEACE.

Ever since Hotspur declaimed against "villainous saltpetre" nitrates have become more and more essential in warfare. In 1810–12 we very seriously hampered Napoleon's campaigns by cutting off his oversea supplies of saltpetre, and he had to appoint a committee of scientific men to devise artificial methods of producing it. In 1916 we ourselves had to consider what might be the effect of the submarine campaign upon our importation of Chile nitrates, which were essential to the manufacture both of propellants and explosives. Had this source been suddenly closed to us we should have been in grave difficulties although the resources of science have greatly expanded since the Napoleonic times. Even now, although the U-boat menace is becoming less threatening, the shortage of shipping from that and other causes enforces the necessity of producing everything at home which is possible. We, like all other countries, have abundant supplies of nitrogen in one form or another, but not in the state in which it is required for the manufacture of explosives. Nitrogen in countless millions of tons exists in the atmosphere, while it is an element in all animal and vegetable life. It is the latter source which has provided the immense stores of nitrogen in our coal, very little of which we utilise, and it was to that source which we naturally turned immediately we realised the danger that threatened us. The Germans, it is understood, early in the war put up works for the production of nitrates from the atmosphere, following the lead set some years ago in Norway, but without the advantage of cheap water power. For some time also they had been working at the catalytic production of synthetic ammonia, and had attained very considerable success in it. We, as usual, had done very little, preferring to stand on the ancient ways, and therefore when the Ministry of Munitions appointed the Nitrogen Products Committee that body found itself faced by a very large and difficult problem. The committee comprised 24 members, all of them of first rank in their respective spheres, and it divided itself into sub-committees on processes, economics, experiments, power, and general purposes. These immediately got to work upon the six items in the terms of reference which briefly were: (1) the cost of the fixation of atmospheric nitrogen; (2) the supply of pure nitrogen and hydrogen; (3) cheap power; (4) national resources in nitrogen-bearing compounds; (5) experimental work in various processes and (6) recommendations as to starting operations on an industrial scale.

The earliest step was the organisation of a suitable staff and the acquisition of the new Ramsay Laboratory at University College, London. The first subject put before the staff of chemists was the production of synthetic ammonia by the Haber process, in which hydrogen and nitrogen are combined by the aid of catalysts. When the ammonia is obtained, either synthetically, or from coal in gas works, it can be burned to nitrogen oxides* and used directly in the lead chamber process for the production of sulphuric acid, or it can be converted into nitric acid for the nitrification of glycerine or cotton, or other bases of explosives.

Much had been heard in the country in a general way about the Haber process, but there was very little really definite information available. The committee were fortunate in securing the services of a chemist who had previously worked for some time on the problem in the laboratory of Professor Haber at Karlsruhe. Towards the end of 1916 the committee came to the conclusion that the ammonia oxidation process was well adapted as an emergency measure for securing quickly a considerable output of nitric acid or nitrates. In the meantime our existing sources of supply of ammonia, that is, the gas works and coke ovens, were being made use of to the fullest extent, and known sources of loss of ammonia were being removed.

Early in 1917 the committee issued an interim report in which they recommended: (*a*) the increase of output of by-product ammonia, (*b*) the erection of an ammonia oxidation plant capable of producing 10,000 tons of nitric acid per annum from gasworks and coke-oven ammonia; (*c*) the erection of a factory to produce 50,000 tons of cyanamide annually; and (*d*) the erection of a full-sized trial unit plant for the synthetic ammonia process. The Minister of Munitions immediately authorised an action under (*a*), and undertook himself the installation of Government plant for ammonia oxidation; or, if preferred, to allow private firms to erect the plant. He also authorised the erection of a full-sized synthetic ammonia unit (*d*). Further inquiries as to the cyanamide process (*c*) were requested. The Explosives Department was already in close co-operation with the gas companies to increase the output of by-products, and it undertook the duty of looking after ammonia as well. In regard to ammonia oxidation a conference of chemical manufacturers was called in March, 1917, and several undertook to erect experimental plant on a considerable scale. Meanwhile the research was continued and plans were got out for the erection in London of a single commercial unit designed to give a daily output of one ton of strong nitric acid. The Explosives Department, however, requested that the establishment of the process on a commercial scale for the manufacture of nitric

* See Engineering, November 3, 1916, page 440.

acid and ammonium nitrate should be handed over to them, and this was done last August.

Further inquiries as to the cost of the cyanamide process were made at home and abroad, and plans for a large factory are in course of preparation. Cheap power is an essential element in the fixation of atmospheric nitrogen, and some schemes for the utilisation of water power in the British Isles are being considered. A survey is being made of a drainage area in one case, but as the engineering work will occupy two years it does not promise results available during the war. The generation of power from coal by methods involving carbonisation and gasification, with recovery of ammonia, fuel oils, and other by-products, is of more immediate interest, and there is the possibility of its being attempted on a large scale.

The studies in the synthesis of ammonia have led to the devising of a method whereby the output per unit of catalyst space has been increased to a figure which, as far as is known, exceeds anything hitherto attained. The semi-technical unit apparatus now at work, will enable the remaining problems involved in the design of the full-sized unit authorised to be definitely settled. The most immediately important outcome of the conference with manufacturers has been the introduction of the ammonia oxidation plant to take the place of the nitre-pots used in the manufacture of sulphuric acid by the lead chamber process. In pre-war times the annual consumption of Chile nitrates for this purpose was 18,000 tons, and recently it has been much greater. Messrs. Brunner, Mond and Company some months ago installed one of the small converters designed in the Departmental Research Laboratory, and are now arranging to adapt similar converters to the whole of their leaden chambers. Other manufacturers are preparing to follow the same course, and an explanatory pamphlet is being got out to assist them.

For the present our thoughts are mainly directed towards the war, but the supply of nitrogen compounds is very important in peace time, especially as the world is threatened with a general shortage of crops, and needs to get as much as possible out of the ground. Nitrogen, potash and phosphorus are the main elements in maintaining the fertility of the soil, and we have, in the past, been largely dependent for the first upon the deposits in Chile, which are rapidly diminishing. Norway has sent us cyanamide, and at the same time we have exported sulphate of ammonia. After the war the scarcity of food will continue for a long time, and there will be a wide outlet for nitrates for the intensive cultivation of the soil, both here and abroad. There is no fear that the new plant which is being devised will be thrown out of action when the demand for cordite and T.N.T. ceases.

In the course of these experiments and inquiries the committee have acquired a great amount of information valuable to others as well as themselves. It is quite possible that other committees may be actually searching for the same facts for different purposes, and in so doing wasting their own time and that of manufacturers. The committee have already put themselves in communication with the Fuel Research Board on the question of the carbonisation of coal, with the Admiralty on the production of hydrogen on a large scale, and also with the Explosives Department, the Board of Agriculture and the Board of Trade. They have further prepared for official use a general report on the nitrogen problem and the work of the Nitrogen Products Committee, and this has been printed by His Majesty's Stationery Office. We are indebted to it for much of the information in the above paragraphs.

APPRENTICESHIP TRAINING SCHEMES.

In theory, at least, all progressive employers of labour in the engineering industries are satisfied that the training of apprentices, as it has existed in the past, is no longer adequate to meet the demands of the present day, either as regards the efficiency of the individual as a worker and a citizen, or as regards the future prosperity of industry as a whole. The numerous meetings and conferences of leading employers which have recently been held to consider this problem of apprentice training, as well as the large measure of approval which has been accorded to the provisions of the recently introduced Education Bill, give ample proof of the real interest and sympathy with which all interested regard the proposals for betterment. So far this interest has mainly been expressed in the formulation of proposed schemes of training, the working of which in practice has, in the majority of cases, still to be tested under actual working conditions. The paper contributed by Mr. A. P. M. Fleming to the Institution of Engineers and Shipbuilders in Scotland, containing as it does an account of the work which has already been done in this connection at the works of the British Westinghouse Company, should therefore appeal directly to those employers who, while agreeing in theory with the substance of the proposed training schemes, yet feel doubtful as to their practical application in the modern engineering shop. The fact that the scheme in operation at the British Westinghouse Company's works conforms closely to the lines of the schemes put forward at recent meetings of employers and educationists should make the paper of additional value.

The essential features of these schemes are: (1) Apprenticeship should start about the age of 16 years, after the youth has had a good general education; (2) instruction in the practical work of the shop, the theoretical principles governing good workshop practice, and such subjects as will promote the physical and moral well-being of the students, such instruction to be given during a portion of the normal working hours, and preferably within the works, and the time thus spent at classes to be paid for at the same rate as shop work; and (3) the ensuring of facilities for the higher education and ultimate advancement of youths of ability and character. The value of Mr. Fleming's paper is greatly enhanced by the fact that he gives at first hand much valuable information as to the practical working of such a scheme in a large engineering works. In his introduction the author sets forth the advantages to the State, the industrial community and the individual which must follow upon a national scheme of education for those upon whom the brunt of the coming industrial war will fall, and incidentally points out the grave defects of the existing system under which some employers exploit the productive capacity of apprentices to the future detriment of all concerned. The scientific selection of the boy for the job is advocated and the possibilities of the works classes in providing data for this selection are pointed out. At the Westinghouse Company's works psychological tests are carried out in order to provide data upon which to base a determination of the inherent qualities and aptitudes of individual apprentices, and in this way to place each individual at his post of maximum utility. Apprentices at the British Westinghouse Company, to the number of about 400, spend 5 hours per week at the school on the works premises. In the early stages their general education is continued, but with an industrial bias. This instruction includes sketching and how to read a blue print, and some fundamental notions of industrial economics are put before the apprentices. Later, they are taught the scientific principles underlying their different trades. Those who are entering the electrical trades are given a broad working knowledge of electro-magnetic phenomena. They are instructed in the characteristics and preparation of the materials they use, the manufacturing processes, and the development of shop tools. In the final stages of the school work, experts from the shop, including leading foremen, give trade demonstrations and lectures to the apprentices, each in their several trades. The lecturers are drawn from the company's staff, and most of them are university graduates. The future lecturing staff will, to a large extent, be drawn from leading apprentices who have shown some aptitude for teaching, and who are being specially trained as junior teachers, for ultimate use as senior lecturers.

One of the objects in introducing foremen into the scheme is not only to teach the foremen, but also to bring about a close contact between them and the apprentices. This contact removes the diffidence which many of the apprentices feel in approaching the foremen with their difficulties. The boys are paid at their normal rate of wages during the time spent in the school, and all books, stationery, &c., are provided. Each year 20 boys are sent to the Municipal School of Technology for the day-apprentice course, these youths being selected partly on their work-school record and partly from their shop records, and by such means provision is made for the upward mobility of apprentices with ability.

The difficulties due to the dislocation of industrial processes and to the opposition of foremen have, Mr. Fleming states, been surmounted quite well, and the opposition of the foremen has now changed to a preference for the boys who have been in the school. Among the important advantages of the works school as compared with a central school for the boys from a group of works, Mr. Fleming points out that the school period can be arranged with a minimum dislocation to manufacturing processes, there is a minimum of lost time getting to and from work, the lecturers are dealing with actual works problems, and the close connection established between the apprentices—the workers of to-morrow—and the lecturer—the manager of to-morrow—makes for the ensuring of industrial peace in the future. Provision for the social and physical well-being of the apprentices is made through the agency of a Trades Apprentice Association run by the boys and embracing such activities as summer camps, cricket, football, boxing, dances, whist drives, publication of a magazine, lectures, &c. In this connection it is of interest to note that the author prefers this arrangement, whereby the Association is conducted by the boys with the assistance of their class lecturers to the more usual arrangement where welfare work is in the hands of a specially-appointed supervisor.

With regard to the training required for the higher staff appointments, all will agree with Mr. Fleming as to the need for the highest possible technical and scientific training, but it is well to recognise the fact that the successful management of any large industrial concern is by no means solely dependent upon scientific and technical knowledge. The ability to select and inspire confidence in the right type of assistant, to win and keep the respect and confidence of all ranks, not only in his technical ability, but also in his capacity for fair dealing, are essential to success, and these qualities are as a rule only to be acquired by the broad-minded student through contact with the workers.

The description of actual achievement at the works of the British Westinghouse Company, together with the author's notes on the position of apprentice education in America, Germany, &c., cannot fail to prove stimulating to those employers who are now making an effort to prepare for the future, and if further inducement to apply some such scheme of education at the earliest possible moment were required it would be found in the author's conclusion that the surest guarantee for harmonious relations between employers and employees in the future lies in the proper education and training of the workers of the future.

The papers read by Mr. F. Hope and Mr. A. M. Heppell before the Newcastle Branch of the Association of Engineering and Shipbuilding Draughtsmen, on the 9th inst., are interesting not only because of the audience, but also of the different viewpoint. Briefly, the scheme proposed by Mr. Hope is that all boys from the ages of 14 to 16 should attend either a secondary school or a technical school in order to obtain a satisfactory groundwork in such technical subjects as form the basis of all shipbuilding operations. At the age of 16 the apprenticeship, whether in the drawing office or the works, would commence, and thereafter instruction would in practically all trades be continuous during the apprenticeship. In the case of the drawing-office apprentice, about 10 hours of each working week would be devoted to class work in naval architecture and the allied sciences, while in the case of the shipyard apprentice about 8 hours per working week would be devoted to trade and technical instruction. In the case of shipyard apprentices the author advocates the giving of such instruction within the works, while in the case of youths showing exceptional ability, facilities should be given for their transfer to the instructional course for drawing-

office apprentices. From this it will be seen that the scheme does not vary greatly from several which are already in operation and which are in essentials very generally approved. The practical value of the paper would have been enhanced had Mr. Hope given some particulars as to how the difficulty created by the absence from work of, say, rivet boys, is got over.

In advocating the thorough and systematic training of drawing-office apprentices and the possession of an association diploma as an essential to membership of the Association of Engineering and Shipbuilding Draughtsmen, Mr. Hope is working on the right lines and is deserving of the support of all who have the best interests of this young but virile association at heart. One of the real problems which the association must solve in its effort toward improving the status of draughtsmen is the elimination of the semi-skilled worker the man with a certain facility for the production of drawings varying only in minor details from those of some previously-built vessel, but without the ability to produce original work. In shipyards, particularly, there are at the present time many draughtsmen with only the most rudimentary knowledge of the theoretical side of their work and often little or no knowledge of practical work. In seeking to alter this, Mr. Hope is working for the best interests of all concerned, but it may be permissible to suggest that the time spent by the drawing-office apprentice at practical work in the yard might with advantage be two years instead of the six or nine months suggested.

In his paper, Mr. Heppell agrees generally with the suggestions put forward by Mr. Hope, and calls attention to certain defects in the organisation of technical classes for engineering apprentices. Mr. Heppell says: "The engineering student does not attend classes in order to improve his education, but in order to qualify for the best posts available in his profession." "This fact is not sufficiently recognised by those in charge of our evening schools." The author also deplores the fact that the certificates issued by the Board of Education are to a large extent being substituted by certificates issued by the local Educational Committee. In the majority of educational centres the decentralisation of control indicated by the withdrawal of Board of Education certificates in the earlier stages of technical subjects has been welcomed as affording just that measure of freedom in the arranging of the courses of study which is of such immense importance in meeting the local requirements of industrial areas, and in general it has been found that local educational committees have taken advantage of this freedom to bring their classes in line with local requirements. To those who aspire to the best posts available in their profession no harm will come from the change, as they will naturally pass on to the technical colleges or universities, while to the ordinary apprentice who will remain a manual worker (probably about 90 per cent. of the total number of students) the possession of a sound working knowledge of his trade and of the elementary principles underlying it will be of much greater value than any certificate, whether issued by a local committee or by the Board of Education. The affiliation of local technical evening classes with and under the inspection of a central technical college of recognised standing as at present carried out in Scotland, has proved of very considerable benefit to all concerned, as not only are the local certificates accepted by the technical college in the case of those youths going forward for the higher courses, but the system serves a very necessary purpose in relieving the congestion in the more elementary classes at the technical college. No objection can be raised to Mr. Heppell's suggestion of the granting of certificates or diplomas issued by committees representing trade or professional associations, but there does not seem to be any valid reason why this should not be incorporated with the present technical class arrangements.

German Industrial Amalgamation.—The Bismarck Hütte has acquired the Westphalian Steel Works, principally, if not exclusively, in order to become possessed of the Neue Hardt mine, which produces several ores of high value for the iron and steel industry

NOTES.

Potash from Feldspar.

The available potash of the soil is largely derived from minerals of the feldspars of the orthoclase type; in other feldspars lime and soda predominate. In its natural, very slow decay, weathering feldspar passes finally into kaolinite, aluminium silicate, while the soluble alkali salts are washed out. The direct extraction of the alkali from the feldspar is impossible, since feldspar is not soluble and is hardly attacked by most reagents. The modern attempts to recover the potash of feldspar aim at rendering the potash in the mineral soluble or at volatilising it at high temperatures, and so far these processes have hardly promised technical success. It occurred to Messrs. J. C. W. Frazer, W. W. Holland and E. Miller, of John Hopkins University, Baltimore, that there are certain minerals, especially leucite, intermediate as to chemical composition between feldspar and kaolinite, and these minerals are attacked by acids. They do not maintain that leucite is formed in the soil; so far as we are aware, in fact, leucite occurs only in volcanic rocks. But Frazer and his collaborators found a way of converting orthoclase into a kind of leucite. That they make use for this purpose of so expensive a reagent as caustic potash looks unpromising at first sight; but their artificial leucite has some valuable properties. The process, which was described before the June meeting of the American Institute of Chemical Engineers, is as follows: The finely-ground feldspar is mixed with 0.8 of its weight of caustic potash (or caustic soda) and some water; the mixture is heated in an iron vessel, until the water has evaporated, and then further heated to 275 deg. or 300 deg. C. for an hour. The resulting reaction may be represented by the equation: $KAlSi_3O_8 + 2\,KOH = KAlSi_2O_6 + H_2O + K_2SiO_3$, that is, feldspar and caustic potash yield an artificial leucite (containing all the potassium and aluminium of the feldspar, but only two-thirds of its silica), water and potassium silicate. The leucite, insoluble in water, is separated from the silicate and any excess of potash and water by filtration; the leucite is then carefully mixed with just sufficient diluted hydrochloric acid to bind the potassium as potassium chloride, which is again filtered off. tin excess of hydrochloric acid would bring aluminium in solution, and has to be avoided. Thus the potash of the feldspar is gained. The aluminium is obtained by decomposing the aluminium silicate with sulphuric acid, when aluminium sulphate and gelatinous silica are produced; on heating this mixture the silica turns insoluble, and the aluminium sulphate can be lixiviated. The potassium silicate from the first reaction contains all, or nearly all the potash, which was added for attacking the feldspar; this potash is recovered by decomposing the alkali silicate (water-glass) with lime. In this way the materials consumed would be feldspar, hydrochloric acid and lime, whilst the caustic potash would be recovered; the potassium chloride and aluminium sulphate represent the valuable products of the process. The yields are said to be satisfactory.

Russian Metallurgical Works.

In the course of a lecture he delivered on October 26, before the Société des Ingénieurs Civils de France, Mr. A. Gouvy, who had recently returned from Russia, showed the grouping of the iron and steel industries of that country, comprising notably the iron mines of the Ural region and, in the south, the Donetz collieries and the iron mines of Krivoïrog and Kertch. The output of the Donetz coal basin in 1913 amounted to 16,300,000 tons of bituminous and coking coal, and 4,000,000 tons of non-bituminous coal and anthracite. Fresh coal deposits had been found at Kouznietzk, in the Altaï region, Siberia, and at Otchemtchyr, in the Caucasus. The total production of naphtha in 1913 was 9,167,000 tons. Water power in Russia would seem to have but a limited future, owing to the configuration of the ground, the unfavourable conditions of the rivers and the climate. Among the other combustible materials used in iron-making are wood and charcoal in the Ural region, also peat, but this latter has been but little resorted to so far. In regard to iron ore, Russia's output is 9,500,000 tons; her highest export was reached in 1907, when 900,440 tons left the country, as against 470,000 tons in 1913. The rich and pure Krivoïrog ores enter in the total output for 6,400,000 tons, and the Kertch ores for 480,700 tons, whilst in the Ural the output is only 1,800,000 tons, owing to the necessity in which the Ural blast-furnaces are placed of working exclusively with charcoal fuel. It is contemplated later to use coke made from coal proceeding from the Krouznietzk basin above referred to. The iron ore reserves in the Ural are estimated at 70,000,000 tons. Manganese ore comes mainly from the Caucasus, where the highest output was reached in 1911, with 469,000 tons, whilst the Nikopol deposits yielded only 200,000 tons of concentrated ore. Russia produced 4,695,000 tons of pig-iron in 1913, as against 2,467,900 tons in 1903. In 1913, the Russian output in rolled steel material was the following: Sections, girders, &c., 2,215,550 tons; plates, sheets and flats, 951,770 tons; rails, 652,560 tons, or a total of 3,819,880 tons, against a total of 2,118,600 tons in 1903. Taking the pig-iron output and the year 1913, the Dniéprovienne Company, Kamenskoïé, comes first, with 418,000 tons, followed closely by the Briansk Company with 410,600 tons. The first of these two companies has gas engines both for supplying the blast to the furnaces and for the production of electric current, and its annual coal expenditure for firing steam boilers is 75,000 roubles. At the Briansk works, the electric current is produced by turbo-generators, and its expenditure is 726,000 roubles, which could be reduced by half by using low-pressure turbines taking the exhaust steam from two reversing rolling-mill engines. The Briansk Company owns large works at Biejitza, near Orel, and has recently built a large bridge and structural factory, 500 m. (1,640 ft.) in length; it is so far the only Russian works to manufacture slag cement. The Russo–Belgian Company, at Enakievo, has an output of 348,400 tons of pig-iron; its rolling mills are gas-engine driven. The Hughes works, of Youzovo, are located on their own coal basin, which yields coal of a superior quality, and the whole of its motive power, owing to this fact, is produced by steam derived both from coal and from blast-furnace gas. The Donetz–Yourievka Company, on a coal basin, has five blast-furnaces producing 247,900 tons; this company has dismantled its Bessemer plant and produces steel from liquid pig-iron and ore in seven open-hearth furnaces which yielded 252,700 tons of ingots in 1913. A portion of its pig-iron is sent to the Tzaritzine works on the Volga, these works using exclusively naphtha as fuel for steam raising, in the open-hearth furnaces in the reheating furnaces, as well as for the engines of the power station. The Makeevka works utilise the whole of their blast-furnace gas; the coke is delivered directly to the blast-furnace top by aerial cable. These works have electrified the greater part of their rolling mills. Among the other metallurgical works referred to by Mr. Gouvy we may mention the Nikopol–Mariupol works, at Sartana, which have an armour-plate mill (rolls, 1.250 m. = 49.20 in. in diameter × 4 m. = 13 ft. 1 in. in length); the Konstantinovka works, who own a 40-ton open-hearth furnace heated by coke-oven gas; and the Souline works, whose blast-furnaces are run partly on anthracite.

Trading with the Enemy Act.—The Controller of the Foreign Trade Department has issued a new list (No. 40) of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this list can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

Contracts.—Some large pump sets have recently been supplied by the General Electric Company, Witton, Birmingham, to an allied Government, consisting of 228-h.p. and 354-h.p. "Witton" motors coupled to Rees "Roturbo" pumps. The motors were constructed to operate on a 500-volt, 50-cycle circuit, and to run at 1,470 r.p.m., being direct-coupled to the pumps. They are of the induction type with forced ventilation, and have their slip rings in totally-enclosed covers. The Rees Roturbo pumps have a capacity of 15 cub. metres of water per minute when operating, respectively, against total heads of 45 m. and 70 m. The units are mounted on combination bedplates. For starting, liquid starters were supplied.

THE LATE MR. CHARLES HAWKSLEY.

Very many of our readers will learn with regret the sudden death of Mr. Charles Hawksley, which occurred at his residence, 60, Porchester-terrace, Bayswater, last Tuesday afternoon. Although he was well advanced in years, his decease was not expected, for he was present at a meeting of the Institution of Civil Engineers only a few days previously. His death will leave a gap not easily filled in the councils of the two great Institutions of which he had been a member for many years. He played there an unostentatious part, doing much good work in a conscientious and painstaking way, and deeming no labour too irksome if the interests of the profession could be furthered. Life had not made the demands on him in his younger days that it had on some of his colleagues, for his father had been an honoured and successful member of the profession, and at his death left him an excellent connection to whom he became a safe and trusted adviser. His years sat lightly upon him, for he had not been through the period of struggle which falls to the lot of many, and up to the last he maintained unimpaired his appreciation of the simpler pleasures of life and the companionship of his friends and colleagues. His memory will be cherished by many to whom he lent a helping hand in a quiet way, for he was exceedingly charitable, and was never more happy than when he was assisting those less favourably circumstanced than himself.

Mr. Charles Hawksley was born in Nottingham on June 17, 1839, and was educated privately and at University College, London. On leaving the latter college he entered as a pupil the offices of his father, the late Mr. Thomas Hawksley, F.R.S., who was also a past president of the Institution of Civil Engineers, and who had a civil engineering practice at 30, Great George-street, Westminster. In 1866 he was received in partnership with his father. After the death of the latter, in the year 1893, Mr. Charles Hawksley continued the practice of the firm at Great George-street, and subsequently, in 1900, took into partnership in the firm his son, Mr. Kenneth Phipson Hawksley, so that the firm has continued in London since 1852 down to the present time. The name of the firm is chiefly associated, and that to a great extent, with water works engineering in Great Britain, although it also practised in a very considerable way in connection with gas undertakings and sewerage works for various towns.

Among the many water undertakings for which Mr. Charles Hawksley acted in the capacity of consulting engineer since he became the head of the firm after his father's death, we may mention those of Bristol, Barnsley, Cambridge, Coventry, Consett, Derby, Darlington, Devonport, Folkestone, Great Yarmouth, Lowestoft, Newcastle and Gateshead, Norwich, Rochdale, Sunderland, Southend, Weardale, Yeovil and York. The principal gas works he was connected with were those put down at Derby, Darlington, Gosport, Oxford and Sunderland. Mr. Charles Hawksley had also, as above stated, a considerable practice in connection with sewerage works, notably with the Birmingham Main Drainage, the drainage of Haylesbury, Yeovil and other towns. For all these water, gas and sewerage undertakings he acted as consulting engineer and was responsible for the designing and the carrying out of the work. For at least fifty years the subject of the present brief memoir was a prominent figure in the Committee Rooms of Parliament, where he frequently gave evidence on civil engineering matters.

He was elected a member of the Institution of Civil Engineers in 1867, and was appointed President in 1901, immediately following the late Mr. James Mansergh. Mr. Charles Hawksley was also a member of the Institution of Mechanical Engineers, having been elected in 1870, and at the time of his death was a member of council of the latter Institution. It will be remembered in this connection that Mr. Charles Hawksley founded in 1907, to commemorate the centenary of the birth of his father, the late Mr. Thomas Hawksley, a lectureship of the Institution of Mechanical Engineers. The first lecture was given by the late Mr. E. B. Ellington, past president, in 1913, on "Water as a Mechanical Agent." This was followed the next year by a lecture by Mr. W. B. Bryan, chief engineer to the Metropolitan Water Board, on Pumping Machinery. The fact that Mr. Bryan's early experiences were gained largely in works designed by Mr. Hawksley rendered his selection as lecturer specially appropriate. Mr. (now Sir) Dugald Clerk continued the series in 1915 by speaking of the Conservation of Coal. This subject was not so intimately connected with water supplies as those of the two preceding lectures, but it was germane to them, since economy in coal consumption is a matter of great importance in pumping machinery, and some of the best results ever attained have been in connection with such plant. In 1916, Mr. Thomas Hawksley's long and successful connection with the gas industry was commemorated by a lecture on The Gas Engineer of the Last Century, delivered by Mr. Harry E. Jones. By a melancholy coincidence the lecture for this year is to be delivered this evening in London, and next week in Manchester and Birmingham. The fund provided for the Hawksley lecture also covered the award annually of a gold medal for the best original paper published in the Proceedings of the previous year. This may also be accompanied by a Thomas Hawksley premium. This medal has been awarded twice, but it is only recently that the design has been completed. In conjunction with Mr. E. B. Martin, Mr. Charles Hawksley read a paper in 1877 before the Institution of Mechanical Engineers on "Special Mechanical Appliances for Meeting the Requirements of certain Classes of Mine Accidents." He frequently attended the meetings of both the above Institutions, and was also a very active member of the board of management of the Royal Institution, in which he took a deep interest. He was, moreover, connected with many of the other scientific societies of the country.

Thos. Fall, Photographer.

The late Mr. Charles Hawksley.

Mr. Charles Hawksley's address as president of the Institution of Civil Engineers, which was delivered in the first year of the present century, and also in the first year of the reign of King Edward VII, took the form of a review of the engineering progress made in the nineteenth century, and constituted a most interesting compendium which covers the whole field of engineering practice. It is seldom that a president has so good an excuse for recording the progress over a long range of years and of instituting comparisons between the state of knowledge of ourselves and our fathers and grandfathers. It is easy to demonstrate that we know far more than they, but it is quite another matter to show that we can make better use of our knowledge. When inducting him in the chair on that occasion, the late Mr. James Mansergh, the retiring president, stated that "those who knew Mr. Charles Hawksley best, and who, like himself, had had him as a keen professional opponent in another place on many occasions, knew him to be a courteous, kind-hearted and loyal English gentleman of the first water." No words of ours could better describe the character of the deceased. But we may be allowed again to call attention to the very significant fact, that the firm of T. and C. Hawksley is, perhaps, unique in the following respect. It was founded in 1852 by Mr. Thomas Hawksley, the pioneer of water engineering in the nineteenth century; it was continued by Mr. Charles Hawksley up to the date of his death, and it now passes on to his son, Mr. K. P. Hawksley, who has already shown himself to be a very able engineer. Further, and in order to show the traditions of the office, we may also state that the managers of the various departments and four-fifths of the staff have served under all three generations. This is a most remarkable example of the loyalty and mutual respect which exists between engineers and their staffs. The relationship in this case during three generations has always been of the most friendly nature.

Mr. Charles Hawksley leaves two sons and two daughters; his wife predeceased him in 1911. A memorial service, at which the attendance of members of council will be welcome, will be held at the Essex Unitarian Church, The Mall, Notting Hill Gate, W., at 11.30 a.m. on Saturday next, December 1.

LITERATURE.

Atoms. By Jean Perrin, Professeur de Chimie physique à la Sorbonne. Authorised translation by D. Ll. Hammick. London: Constable and Co. 1916. [Price 6s. net.]

In reading Professor Perrin's book we are conscious of the same kind of intellectual excitement that we experience in listening to a lecture at the Royal Institution, when a profound master of some abstruse problem to which he has devoted the study of a lifetime, spreads before us the outcome of his work, and by lucid arrangement and clear expression smooths away all difficulties. But we only hear the lecture once; the art of the expert contrives a clever dissection of so much of the problem as will prove interesting, and he has the opportunity to ignore those uncomfortable facts that will not blend spontaneously. By guiding us discreetly towards the desired goal and not allowing the issue to be obscured, we are dismissed in the full belief that our intellectual horizon has been widened and that new truths have been assimilated. M. Perrin essays a harder task, but is equally successful. He has to make a statement of facts that can be sifted at leisure; his arguments have to be logically complete, and are submitted to a severer criticism—omissions will be detected and will not be tolerated. Whatever test be applied, the Sorbonne professor will not be found wanting. He has rendered a very distinct service to scientific education by presenting the results of recent physical inquiry in a form that is both interesting and exact. He has proved himself as able an exponent as he is a brilliant experimentalist. By his researches he has done much to complete the triumph of the atomic theory, and by his description he will spread more precise views of the laws of radiation and the theory of the discontinuous structure of energy.

The hypothesis of continuity long satisfied the needs of mathematical physics. It explains so much that it must contain a part of the truth, but as much remains outside its scope, it cannot be all true. It was both plausible and convenient to consider every liquid as homogeneous and isotropic, and progress was not hampered by such limitations. When dealing with problems of hydromechanics or elasticity the differential equations implied continuity of the medium concerned. In the study of solid bodies, the theory of crystalline forms implied a discontinuity of structure, but not with sufficient force to disturb accepted methods and principles. The atomic theory was necessary in chemistry, and useful in explaining the phenomena of permeability of solids, for example. But physicists regarded the atomic theory as a picturesque excrescence, and troubled themselves little about the objectivity of atoms, and may have doubted whether atoms had a real existence or were simple fictions invented to remove inconvenient difficulties. Practically, it is only within the last quarter of a century that physicists have been forced by careful experiment to consider the molecular hypothesis as one necessary to natural philosophy. The emission of α particles was perhaps required to convince some of the existence of a complicated mechanism capable of producing visible effects. The phenomena of the Brownian movement—or the motion of very fine particles when suspended in an apparently undisturbed fluid—has still further compelled a revision of the fundamental standpoint.

At critical points in the progress of science, such as that now reached by the study of the minute, if confusion of thought is to be avoided, the necessity of authoritative direction becomes imperative. The author supplies that guidance. Homogeneity acquires a more rigorous meaning, and properties that seemed of negligible importance assume a prominence hitherto denied them. As Professor Perrin reminds us, though there should be no necessity for the caution, the notion of continuity, so uniformly accepted, is the result of an arbitrary limitation of our attention to a part only of the data of experience. With certain magnification and for certain methods of investigation, phenomena may be not incorrectly represented by regular continuous functions. But with continual higher magnification the conception of a curve in the ordinary sense disappears—the smooth curve resembles a staircase—and from a mathematical point of view we have to face the notions of continuous functions having no derivative, or that of continuous curves possessing no tangent. This more general view is well illustrated in the Brownian movement, to which the author devotes an illuminating chapter. It may be easy, as a matter of words, to accept the reality of smaller divisions of matter than those operated upon, and even to contemplate the division of these complicated entities into still more minute systems, but the acceptance leads to conclusions which the older school, supporting the theory of equipartition, would find it hard to entertain. If diminution be carried to an ever-increasing order of smallness, the mean density, owing to the emptiness of intro-atomic space, will continually decrease, but at the central atomic nucleus the density will increase enormously, or, in other words, the doctrine of atoms requires that density should be everywhere nil, except at an infinite number of isolated points, where it reaches an infinite value. The author asks us to consider an infinitely discontinuous matter, possibly represented by a continuous ether studded with minute stars, and also to remember that the same picture is presented by a continually enlarging sphere that embraces planets, solar system, stars and nebulæ, recalling Pascal's image of "man suspended between two infinities." And yet, on the one hand the minute electron, and on the other the distance of the remote nebulæ, are no more a part of infinity than is a single inch.

The opening chapters are devoted to an historical survey of the chemical and physical aspects of the atomic theory, and to a collection of the arguments that led finally to a belief in an atomic structure for matter and electricity. In the hands of early chemists such a theory furnished successfully the ratios between the weights of the atoms, though no knowledge of absolute values was possible. This later information involved the interpretation of the Avogadro constant (N), the importance of which is defined in this preliminary examination, while much of the remaining portion is concerned with the methods that permit its numerical determination. The author's work on the Brownian movement has already been mentioned, but in this aspect acquires a special importance, for the degree of reliance to be placed upon the numerical value, and consequently upon the mass of the atom, is increased by the concordance exhibited by the independent determinations, involving distinct methods of attack. M. Perrin, in connection with the study of emulsions, devised four different methods, in each of which the mass, density and volume of the minute grains varied greatly, the viscosity of the intergranular liquid had very different values, and wide limits were given to the temperature. Nevertheless there is only one method of investigation employed, to be distinguished by the peculiarity that the inquiry is not directed immediately to the number of atoms, but to their degrees of freedom of movement. That the agreement is so close is marvellous, and fortunate, declaring the highest possible skill on the part of the experimentalist. Omitting the common denominator 10^{22}, the following values were found from the study of emulsions for Avogadro's number:

From the vertical distribution of grains	N = 68.2
From their translatory displacements	N = 68.8
From observations on their rotation	N = 65.0
From diffusion measurements ...	N = 69.0

The significant figures that express the mass of the hydrogen atom in grammes are, respectively, 1.47, 1.45, 1.54 and 1.45; the denominator is 10^{24}, a mass that escapes our sense perceptions, but nevertheless the reality of the atom is demonstrated.

This result is confirmed in subsequent chapters, in which the values of the same quantities are derived, involving different properties of the atom. In the blue of the sky the atom can be regarded as producing an optical discontinuity, and in radium experiments the emission of projectiles is the phenomenon observed. Other schemes of investigation possess even greater variation. For example, in Millikan's method of observing falling drops the atom of electricity is the immediate subject of investigation. In this particular case, whence Avogadro's N can be inferred, some uncertainty is introduced by the necessity of applying a correction of doubtful amount to Stokes's law, a device for deducing the mass of the tiny spherule from its known rate of fall in air. This is the kind of detail that makes itself manifest in all experiments, and implies no mistrust or contradiction. Generally the effect can be removed by varying the conditions of the experiment. M. Perrin has himself suggested a modification that promises greater accuracy and a more assured result. His arrangements permit the measurement of the rate of fall of the same spherule in air and liquid, thus dispensing with the use of any correction to Stokes's law. Under such conditions the numerical agreement of the result of Millikan's method with those of other experimenters is a little closer, but Millikan's figures cannot be called discordant, though they may not have quite the accuracy claimed for them. In the final chapter the author collects the various values of N as they have been derived from several distinct sources of observation. These methods include: viscosity of gases; Brownian movement; irregular molecular distribution (as opalescence and the colour of the sky); charged spherules; and radioactivity. Some of these, as was shown in the case of the Brownian movement, can be subdivided, thus giving rise to 13 independent values of N. It is not necessary to quote these in full, for the accordance shown in the figures previously given is repeated, but Professor Perrin's summary is impressive and warranted. "Our wonder is aroused at the very remarkable agreement found between values derived from the consideration of such widely different phenomena. Seeing that not only is the same magnitude obtained by each method, when the conditions under which it is applied are varied as much as possible, but that the numbers thus established also agree among themselves without discrepancy for all the methods employed, the real existence of the molecule is given a probability bordering on certainty."

The atomic theory has triumphed, and the atom is proved to be a reality. But the modern atom, possessing a complicated structure, proves to be something very different from the absolute indivisible atom that the Greeks hoped to attain. They sought finality and quiescence, beyond which no further mystery existed. We are confronted by new operations and the necessity for further investigation; complication and not simplicity has been our reward. There are still secrets to be unravelled: a new universe awaits exploration.

BOOKS RECEIVED.

Minutes of Proceedings of the Engineering Association of New South Wales. Vol. XXXI. Edited by J. McNamara, Honorary Secretary. Sydney: Published by the Association.

With the French Flying Corps. By Carroll Dana Winslow. London: Constable and Co., Limited. [Price 3s. 6d. net.]

The Principles of Iron Founding. By Richard Moldenke, E.M., Ph.D. London: Hill Publishing Company, Limited. [Price 17s.]

Theory and Calculations of Electrical Apparatus. By Charles Proteus Steinmetz, A.M., Ph.D. London: Hill Publishing Company, Limited. [Price 17s.]

Elements of Machine Design. By O. A. Lentweiler, M.E. London: Hill Publishing Company, Limited. [Price 17s.]

Selected Bibliography on Ports and Harbours, and their Administration, Laws, Finance, Equipment and Engineering. Compiled by William Joshua Barney, C.E., Secretary. New York: Published by the American Association of Port Authorities, 29, Broadway. [Price 1 dol.]

Memoirs of the Geological Survey. Explanation of Sheet No. 248. The Geology of the South Wales Coalfield. Part IV. *The Country around Pontypridd and Maesteg.* By Aubrey Strahan, Sc.D., LL.D., F.R.S., R. H. Tiddeman, M.A., and Walcot Gibson, D.Sc. London: E. Stanford, Limited. [Price 3s. 6d. net.]

Terms of Industrial Peace. By Alex. Ramsay. London: Constable and Co., Limited. [Price 3s. net.]

Methods in Metallurgical Analysis. By Charles A. White. London: Constable and Co., Limited. [Price 10s. 6d. net.]

Business Law for Engineers. By C. Hank Allen. Part I. *Elements of Law for Engineers.* Part II. *Contract Letting.* London: Hill Publishing Company, Limited. [Price 12s. 6d.]

Text-Book of the Materials of Engineering. By Herbert F. Moore. London: Hill Publishing Company, Limited. [Price 8s. 4d.]

THE LATE MR. JAMES COMPTON MERRYWEATHER.

We regret to announce the death of Mr. James Compton Merryweather, principal of Merryweather and Sons, Limited, which occurred at his residence, Whitehall Court, Westminster, on Saturday, the 24th inst., after a brief illness. Mr. Merryweather was the second son of Mr. Moses Merryweather, a descendant of an old Yorkshire family, who came to London in 1807 and was apprenticed to the fire-engine business. His son James was born on March 12, 1840, was educated at Chatham House, Ramsgate, and began his training in the locomotive works at Wolverton, this opening being found for him through the influence of the Duke of Buckingham, who was on friendly terms with Mr. Merryweather, senior. After remaining for some time at Wolverton, he became a partner in the firm of McGlashan and Co., coppersmiths, but in 1864, owing to the failing health of his elder brother, he left the latter firm to join his father, who had established a coppersmith's business at Lambeth.

Under his direction this business greatly prospered, and at the same time he was keenly interested in and had a great deal to do with the introduction of steam fire engines. A few years later, on the death of his father, Mr. J. C. Merryweather became head of the firm, and he continued actively in this position. During the last year, his strength began to fail, and he was compelled to take somewhat extended vacations, but he was nevertheless in attendance at Greenwich almost daily during the week previous to his death.

Mr. Merryweather was generally known as "The Fire King." He had a genial manner, which made him very popular.

We have briefly alluded to his work in connection with the introduction of steam fire engines. We may add that in collaboration with one of his brothers he was chiefly responsible for the introduction of steam tramways, which held the field for many years, until they were superseded by the electric system. Primarily an engineer, he was also a business man of great ability, and under his able direction his firm in recent years acquired world-wide renown as pioneers of the motor fire-engine industry.

In the course of his long business experience Mr. Merryweather designed the fire protection at Sandringham and other Royal residences in this country, and on one occasion he travelled to Egypt and drew up a scheme for the protection of the Khedivial Palaces, being made a Commander of the Imperial Order of the Medjidieh in recognition of his services. During recent years he was unable to take an active part in local work, but up to the time of his death he remained vice-president of the West Greenwich Constitutional Club. He was an active supporter of the Miller General Hospital, Greenwich.

A man of wide human sympathies, he was able to maintain cordial relations with his staff and workpeople throughout the industrial unrest of recent years. During the half-century of his business life as an employer of labour there was only one instance of a strike at his works, and even this was speedily brought to an end by mutual agreement. Such a record could only be held by one who deservedly possessed the confidence of his workpeople. He held another record of which he was accustomed to speak with pleasure; no workman had ever been killed through an accident while employed in his factory. He knew his men by name, and he knew also their duties and their capabilities, and whilst he remained a keen disciplinarian he invariably, in his decisions, tempered just decisions with sympathetic consideration.

Mr. Merryweather was a member, since 1875, of the Institution of Mechanical Engineers.

He had a large circle of friends, among whom the members of his staff at Greenwich were proud to number themselves, and his genial presence will not readily be forgotten by those who were privileged to know him best.

With the addition of two directors to the Board the business of the company will go on as usual, and the late Mr. Merryweather appointed as executors and trustees under his will, Mr. W. G. Rayner, Dr. G. E. Haslip, and Mr. John H. Osborne, the latter a director of the company.

The Institution of Automobile Engineers.—The third ordinary general meeting of the Institution of Automobile Engineers will be held at the Royal Society of Arts, John-street, Adelphi, W.C., on Wednesday, December 12, 1917, at 8 p.m., when Mr. A. E. L. Chorlton will read a paper entitled "The Agricultural Power Unit—Some Factors Governing the Design of a Small Tractor," a subject which should be of special interest at the present moment. Cards of invitation to the meeting may be obtained on application to the Secretary of the Institution of Automobile Engineers, 28, Victoria-street, Westminster, S.W. 1.

AN ADMIRALTY SHIPBUILDING COUNCIL.

The following official announcement has been made, but until more precise information is given as to the full composition and functions of the new council, we refrain from comment:—

The Admiralty announce that the formation of a Shipbuilding Council has been approved under the chairmanship of the Admiralty Controller. On this council representatives of the shipbuilding and engineering trades will be joined by officers of the Admiralty, and problems of naval and commercial shipbuilding and repair will be considered. The council differs from the Shipbuilding Advisory Committee by the inclusion of naval shipbuilding in its purview, and by being relieved from certain executive functions in the placing and following up of contracts which have been undertaken by the Admiralty Controller and Director of Contracts.

All the gentlemen who served on the Shipbuilding Advisory Committee, and who have not since joined the staff of the Controller's Department, have already consented to serve on the council, and the full list will be published shortly. The names of those gentlemen who have already notified their willingness to serve on the body are:—Mr. W. S. Abell, chief surveyor of Lloyds; Sir George Carter, K.B.E., managing director of Messrs. Cammell, Laird and Co.; Mr. F. N. Henderson, of Messrs. D. and W. Henderson, shipbuilders, Glasgow; Mr. James Marr, of Messrs. J. L. Thompson and Co., shipbuilders, Sunderland; Mr. A. C. Ross, director of Messrs. Hawthorn, Leslie and Co.; Mr. H. B. Rowell, chairman of Messrs. Hawthorn, Leslie and Co.

Other prominent members of the shipbuilding and engineering trade who have joined the Controller's Department, and who will attend meetings of the council when matters affecting them are discussed are:—Major Maurice Denny, partner of Messrs. Denny Brothers, of Dumbarton; Mr. G. S. F. Edwardes, director of Messrs. Smith's Dock Company; Mr. H. M. Grayson, of Messrs. H. and C. Grayson, Limited; Major J. W. Hamilton, chairman of Messrs. W. Hamilton and Co.; Lieutenant-Colonel J. Lithgow, senior partner of Messrs. Russell and Co., director of Messrs. Robert Duncan and Co., and director of Messrs. Napier and Millar; Lieutenant-Colonel J. Mitchell Moncrieff, M.Inst.C.E.; Mr. Noel E. Peck, director of Messrs. Barclay, Curle and Co., Limited, director of Messrs. Swan, Hunter and Wigham Richardson, Limited, ex-vice-president of the Shipbuilding Employers' Federation, ex-chairman of the Clyde Shipbuilders' Association; Mr. A. W. Sampson, late director of Messrs. Fairfield Shipbuilding and Engineering Company; Mr. W. Rowan Thomson, senior partner of Messrs. David Rowan and Co., ex-chairman of North-West Engineers' Association.

Germany's Commercial Campaign in France: Erratum.—Under the above title, in our issue of September 7, on page 244, we stated that the Georg Fischer Iron and Steel Works formed the Société Française des Aciéries *ci-devant* Georges Fischer in France, the inference being that the Georg Fischer Iron and Steel Works was a German concern. We now learn that the firm in question has been established in Schaffhausen, Switzerland, since 1804, and that it has received a certificate to that effect from the British Consul-General at Zurich. The business was founded by a member of the Fischer family, whose private property the works remained until they were taken over by the present limited company in 1895. As Switzerland is a bilingual country the firm was registered, in both German and French names, as "La Société Anonyme des Aciéries *ci-devant* Georges Fischer," and "Aktiengesellschaft der Eisen und Stahlwerke vorm. Georg Fischer." In 1904, the company established in Paris the Société Française des Aciéries *ci devant* Georges Fischer, but this concern ceased to exist in 1907. It is clear that the firm of Georg Fischer is an old established Swiss firm and is entirely neutral, and we regret that we inadvertently coupled it with German concerns. It is represented in this country by Messrs. Edward Le Bas and Co., of Dock House, Billiter-street, London, E.C.3.

Permanent Memorial to Women's Work on Engineering Munitions.—It is part of the scope of the Women's Section of the National War Museum that it should contain a permanent collection of engineering exhibits, illustrating the proficiency attained by women in work of an engineering nature in connection with the manufacture of munitions of war. A Special Committee has been formed to undertake the work of collecting suitable specimens, and firms are invited to assist this committee by submitting particulars of such examples as they would be willing to present to the National War Museum. The collection is only intended to illustrate the nature of work which women have undertaken since, and in consequence of, the war; it will include details of aero-engines, aeroplanes, steam and other engines, motor vehicles, machine tools, guns, small arms, projectiles, gauges, cutters and small tools, gun sights and other articles coming within the limitation mentioned. The name and address of the firm giving the specimens may be recorded in a manner approved by the committee, either on the specimens or on the case containing them. It is hoped that firms employing women on engineering work in connection with the making of war material will be willing to contribute specimens which will constitute a permanent memorial and record of the work women have done in the war. Communications should be addressed to the Hon. Secretary of the Women's Work Sub-Committee, National War Museum, 9, Queen Anne's Gate, London, S.W. 1. It is not desired that samples should be sent in the first instance.

DRAUGHTSMEN.

To the Editor of Engineering.

Sir,—In the year 1914, before the war, the pay of draughtsmen was perhaps, on the average, at about the same level as that of workmen in the shops.

Since the war began the men in the shops have, from time to time, demanded—and have received—considerable increases in their wages until, at this moment, the average amount of money received by the men in the shops at each week-end is, probably, double the amount of that received by the draughtsmen—man for man. The reason for this is that the workmen have demanded the increases, whereas the draughtsmen have not demanded them.

During the war the prices of all the principal necessaries of life have risen anything from 50 per cent. to 400 per cent.; to compensate for this some draughtsmen have lately received advances of 20 per cent. in wages.

The Association of Engineering and Shipbuilding Draughtsmen seems mainly to concern itself with "maintaining the status and upholding the dignity of the profession," but even this can scarcely be done without adequate wages. Either a draughtsman is worth as much in wages as a workman, or else he is not. If he is worth as much, why does not his association demand it? If he is not worth as much as the workman, what is the use of airing his supposed "status" and "dignity"?

Yours, &c.,

November 26, 1917. "Waiting."

To the Editor of Engineering.

Sir,—With your kind permission, I should like to refer to the discussion which has arisen from my letter which appeared in your issue of the 9th inst.

I am gratified to note that three gentlemen have appreciated and acted upon the suggestion that careful consideration should be given to the subjects of the registration of the Association of Engineering and Shipbuilding Draughtsmen and its position in regard to Labour. As contended, the subject is of such vital importance and urgency that we cannot be too deliberate in coming to a decision.

Regarding my own contribution to the discussion it appears necessary that I should make a re-statement of the views put forward in my former letter. Briefly summarised, they are:—

1. That these questions cannot be satisfactorily disposed of within the limits of one sentence.

2. That an alliance with Labour does not necessarily follow upon registration as a trade union.

3. That registration merely offers protection and facilities in certain defined circumstances, and in no way effects the present policy of the association.

4. That an alliance with Labour must ultimately affect the policy and constitution of the association; and in the present position of Labour would not be for our good, but to our disadvantage.

From the above outline it will be gathered that "Senior Draughtsman" has been led to mistake my meaning; and that the commentory of "Accelerando" for the greater part is based upon a very superficial and inaccurate reading of my letter. The latter gentleman has, in fact, charged me with holding opinions on registration the very opposite of those I put forward in my letter, and I sincerely trust that he will be more careful before he begins to accelerate.

The question of registration, I am pleased to learn, is being disposed of in another quarter, and our concern now need only be on the question of an alliance with Labour. "Accelerando" indulges the idea that the exigencies of war and the present industrial situation will have impressed many members with the necessity of adopting a trade-unionist outlook and policy. I should say that this is merely a hope which cannot easily be proved. Certainly I agree that it is important that draughtsmen should be represented on the National Industrial Councils; but, as I gather from the Whitley Report (Clause 14B) that all workers, *i.e.*, including non-unionists, are to be represented on the Works Committees, I think there is small reason to suppose that the Association of Engineering and Shipbuilding Draughtsmen, though not strictly speaking a trade union, will be debarred from representation on the national bodies, provided the necessary effort is made.

"Senior Draughtsman" in support of his proposa that we should ally ourselves with Labour, states that the association has been formed to protect draughtsmen against the Masters' Federation. I do not recognise any federation by that name—and I must say that I do not agree that the above is the sole object of the association. To my mind, it would not be worthy of the name of "association" if that were the only community of interest established, and just as draughtsmen, being human and sentient beings, cannot live by bread alone, so the Association of Engineering and Shipbuilding Draughtsmen must not confine itself to negotiating with "masters." The association has been formed to elevate the status of draughtsmen, and while I agree that status is expressed in £ *s. d.*, I contend that status and its monetary expression are based upon ability and function. Consequently, by advocating the "sloppy educational activities"—by the way, who invented this gutter phrase?—some of us humbly aspire to elevate the status of the members by improving the average mental equipment and thus enhancing the functional value of the profession. Further, besides being a draughtsman, a man may be a first violin, a second tenor, a billiard cue, a fair right-half, or an admirer of Lamb, Gibbon or Descartes, and within the association he may discover and pair off with his appropriate partner or opponent. The significance of these secondary activities may not be immediately apparent to those who reverse the above

formula and maintain that status is the expression of £ s. d., but in the future—when it may happen that the association is threatened, when the call comes for unity of action and purpose; when each individual member is required to stand by the organisation which has rendered service to him—these small and "sloppy" things will count for much. This close-knitting of the fabric of the association will, in fact, bring us ever nearer to the ideal of an organisation, so highly and firmly constituted, that in pressing our demands we shall have no need to resort to the strike, which I have described as the last resort of a weak organisation.

I have been extremely interested in Mr. R. J. Lappin's meticulous analysis of the expression "splendid isolation" and his diverting references to getting married, &c.; and I little thought that we should have to immerse ourselves in philosophy in order to settle these questions. To my mind, however, our "isolated" and "unique" position is a very real actuality and by no means a vain assumption. These columns have very recently contained letters from various members claiming in effect that draughtsmen as a body were the brains of the engineering and shipbuilding industries. Not a few employers have conceded the same point, and I fancy that the layman is duly impressed. This general opinion, so stoutly maintained by draughtsmen and condescendingly conceded by employers, is just, and, in my opinion, establishes the draughtsman in a unique position in contrast with other branches of Labour. For this reason we must not be prodigal of our prestige or welfare; and while it is an excellent thing to be large-minded and softhearted towards the world in general, it is "the fool whose eyes are in the ends of the earth." As one of this higher class of industrial workers, and proud of its functional prestige, I consider the idea of joining forces with Labour, at this stage, as a doubtful proposition. The statement that "our position must depend mainly on the general social and economic conditions obtaining" is, of course, a truism; but does not justify the affiliation of the Association of Engineering and Shipbuilding Draughtsmen to the Trade Union Congress or Labour Party. The British Medical Association—who, it is interesting to note, "are their own employers!"—and the Law Society, are each governed by this determinant, but are not allied with Labour. The truth is that the main Labour organisations having extended their power and activities to the widest possible extent, have lost sight of the fundamentals. Thus it appears that the collective mental outlook of these bodies is that the world is peopled wholly by inhuman units called labourers. The idea that a worker is a man with a body to be kicked and a soul to be saved—*i.e.*, the quality of the unit—is overwhelmed by the past quantitative value of the whole. Now, as I have pointed out above, the one thing the draughtsman can pride himself on is the quality of his function, which establishes him in an unique position. Mr. Lappin mentions that the position of lawyers is a direct result of their strict attention to politics. Exactly! that is their business; and just as the lawyer should stick to politics and the shoemaker to his last, so the draughtsman should stick to his designing.

For the above reasons I defend my contention that our policy of splendid isolation has much in its favour. Mr. Lappin may at some time or other have passed across Trafalgar-square at some midnight hour when the moon was full. If he, on such an occasion, had looked up to the effigy of Lord Nelson standing out stark at the top of the column with all the appearance of firmness, stability and strength, he would probably have been impressed with a sense of its guardian benignity over the surrounding populace. In rain, storm, wind or snow its place is fixed, immovable, solitary and unique. There is no bathos in suggesting that the position of draughtsmen is similar, for we find ourselves—not planted upon a pedestal by our own impertinence, but generally acclaimed to hold a superior position, built up by each man with long hours at studies and burning the midnight oil poring over books. We find ourselves the inheritors of the traditions of the men whose work has transformed civilisation within the last 100 years, equipped with the results of their researches and enabled to walk with ease where they could barely climb. Surely this distinguishes the draughtsmen from the rule-of-thumb workmen, and should make them jealous to guard their most valuable possession. Our prestige must be our charge to keep; our standard of ability must be maintained; our position and splendid isolation must be established for the present, by organisation and intelligence. For of what use would Nelson's statue be if it were brought down from its column ,and dropped into the Strand amidst the mob?

Yours faithfully,
FREDERICK H. AUGER.

Newcastle, November 25, 1917.

TO THE EDITOR OF ENGINEERING.

SIR,—I trust you will allow me to reply to your correspondent, Mr. A. J. Knight, who also takes the view that registration as a trade union is a step backward, and with his limited knowledge of what such a course really means, concludes it will end in nothing but strife. He sets forth with "some" dignity the responsible position that he holds, but what his position has to do with registration I fail to see; like himself, many of us can claim to hold equally responsible positions, but all that is beside the mark.

Even if registered as a trade union we can still encourage education, and all that pertains to the well-being of our profession, and I for one would do all that is humanly possible for the advancement of our craft from the intellectual standpoint. Your correspondent states that if you improve status, increased remuneration will follow; with such a statement I entirely disagree.

The only efficiency that is recognised by the majority of our present employers is the efficiency of organisation, and not of the individual.

Let us, as members of the Association of Engineering and Shipbuilding Draughtsmen, drop the individualist spirit, and work with one common aim, *i.e.*, the well-being of our profession.

The individual is always at a disadvantage in making a bargain with his employers, and the sneers and slurs that some of our members have received when making application for war increases should be sufficient to make us all think and act seriously.

In the reconstruction that is to follow the war, collective action is the only thing that will survive.

We see the various combines and working agreements that are already being formed in order to prevent competition amongst the masters; I have not one word of complaint to raise against such a course—that is their own business; but what does concern us, is that the engineering industry will be made up of two or three large combines that will be able to prevent the free movement of the draughtsman from place to place, thereby keeping down our wages to a minimum.

Trade unionism represents the attempt of a body of workers to regulate the conditions of their profession to their interests, and we shall need an organisation that will be strong and able to show a united front.

The principle of collective action is as old as human society, and we owe a debt of gratitude for what the trade unionist has done, *i.e.*, procured shorter hours and more healthy conditions of employment.

The time may arise when federation with other unions will be necessary, and with such a combination, wisely led, much could be done to lift and help forward human society.

I remain,
"SENIOR DRAUGHTSMAN."

CASE HARDENING.

TO THE EDITOR OF ENGINEERING.

SIR,—As an interested, though not very experienced reader of the metallurgical articles appearing in ENGINEERING, I venture to ask if you or any of your readers can give me an explanation of the following case-hardening phenomena.

In two cases, pieces have come out of the case-hardening pot dead hard without any quenching at all. In neither case were the articles hotter than 500 deg. C. when unpacked, but in both cases the articles had been considerably overheated (1,100 deg. C. estimated) owing to the inexperience of the man looking after the furnace (an oil-fired one).

Case 1.—The article was a thimble about ⅝ in. diameter, for a steering connection, made of Ubas case-hardening steel; the compound used was "closed" Kasenit, and the pot made of a 2-in. gas-pipe socket, with a plug either end. After about 3½ hours in the furnace it was taken out and one of the plugs (cast-iron) was found to be partly melted. The other plug was removed when cold. The thimble had a bright silvery appearance, rather resembling that of a surface freshly amalgamated with mercury, and it was quite hard to a file. The fracture was very coarse, as would be expected.

Case 2.—The articles in this case were some small spur gears, about 2 in. diameter, of mild steel. The material was Kasenit, as before, and the box was of sheet steel acetylene welded. These were again overheated, and the box failed, admitting air. The gears were badly pitted on one face, but were quite hard to a file all over.

No doubt there is some very simple explanation of these results, but I have not had the practical experience to know what it is.

Yours faithfully,
"INQUIRER."

IMPROVEMENTS IN STEEL WORKS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have been greatly interested in the synopsis of opinions in regard to efficiencies of mill practice here and abroad, which you published in your issue of September 28, 1917, in the form of a reproduction of a report entitled "Metallurgical and Mechanical Practice in Open-Hearth Steel Works," and in a report of the discussion which took place before the Iron and Steel Institute. I agree most heartily that in this country, especially, the gain in tonnage is due to three elements in the main: First, better cupola practice—the adoption of the duplex process wherever practicable; second, better lay-out of works; and third, adoption of automatic machinery for handling all material, from charging in the cupola to handling the finished product.

It is well recognised, that with the duplex process properly run, an output of nearly three times that of the basic open-hearth alone, is possible, and with no ensuing lowering of the specification requirements. In addition to this, the process used increases the number of types of ore available for use.

In one mill using this process I have seen the cupola charged in the early morning and the charge turned out into finished rails by four in the afternoon ready for inspection. This mill, however, uses a Maori ore, which, without any physic whatever gives a finished nickel steel rail, high in nickel, and has a slight advantage; in addition the ore is extremely low in phosphorus—which again lowers the time required in the open hearth. Ten hours, I should say, is the average time in the most progressive mills from ore to billet.

True, again, the mills in this country are highly specialised, turning out one type of material, but this, in turn, is due to "standardisation," which we harp on to a greater degree, probably, than in any other country. We try to standardise everything—from a valve to our ever-present Ford, and this standardisation, of course, lowers manufacturing costs.

I do not agree with your engineers at all on the question of the three-high mill, and believe that the three-high electric-driven is the only economical type, and that the question of wear on rolls is a minor one, and has been met in two ways—one the material used and the other by re-use. In this country, rolls on showing wear are removed and re-ground for use on larger sizes, so that the actual life of the rolls is as great as in the two-high mill.

The initial cost is quickly overcome by increased tonnage and power costs. On this point I might say that one point has been entirely overlooked apparently by those discussing the subject. They state that the utilisation of the exhaust in low-pressure turbines does away with the loss. Well and good, but sometimes—just for amusements' sake—have some one compute the inertia losses—the acceleration losses of the reversing two-high mill. Steam you can save; but inertia is a dead loss.

As to electric power costs, that, of course, is a local problem. There are in force in a great many factories in this country, and not only steel works, a sliding scale of prices, a flat rate in the case of hydro-electric plants; a flat rate and sliding scale when brought from other than hydro-electric stations. The sliding scale depends on the amount of "off peak" load the particular factory consumes, and furnishes "night power" at an extremely low cost. The total daily cost depends upon the relative amounts of day and night work. This has been found advantageous to the power companies—as well as to the consumers—and is done to prevent the enormous "stand-by losses" of idle boilers during the night when traction and lighting demands are low. At this time power is sold practically at cost.

Yours faithfully,
KARL F. SMITH, M.S.,
Lieutenant, U.S. Navy.

U.S.S. Prometheus, Repair Ship, care of Postmaster, New York, N.Y., November 2, 1917.

WORM GEARING.

TO THE EDITOR OF ENGINEERING.

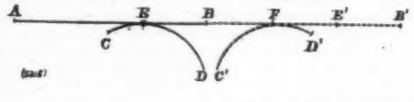
SIR,—In replying to Mr. Pettingill's further letter on the subject of the "velocity of rubbing," I have slightly modified his diagram in order to make the explanation simpler, thus:—

Let A B and C D be two surfaces in contact at E.

Let motion be so imparted to them that after a period of time the point B has travelled along to B^1 and the initial point of contact E to E^1.

At the same time let the surface C D be so moved that the contact in the new position between itself and the surface A^1 B^1 be now at F.

Then the points E^1 and F represent the original and the final contact points, and their distance apart there-



fore represents the amount that the surface A B has progressed beyond that of C D, *i.e.*, the amount of lag of C D or the rubbing that has taken place between them.

Hence in passing from A B to A^1 B^1, which is a distance equal to $E E^1$, the contact has also moved along a distance E F, consequently the difference (F E^1) equals the rubbing.

Now this rubbing has taken place during a period of time, but the velocity is the distance divided by the time.

Therefore the velocity of rubbing is not the velocity of surface A B alone, but it is a combination of the motions of A B and C D.

Resulting, in the aforementioned type of worm gearing, in a considerable reduction in the rubbing velocity from that usually calculated.

Yours faithfully,
FRANCIS J. BOSTOCK.

Park Works, Lockwood, Huddersfield,
November 28, 1917.

THE SURVEYORS' INSTITUTE: PROTECTION DURING AIR RAIDS.—An Advisory Committee of Surveyors has been set up by the Chief Commissioner of Police to consider and report as to the steps which should be taken to provide protection for the population of London during air raids; Sir Alexander Stenning is chairman, and other members of the committee are Mr. Horace Cheston, Mr. Fitzroy Doll, Mr. Percivall Monckton, Mr. E. C. P. Monson, and Mr. Dendy Watney. The Advisory Committee is acting in conjunction with a number of Royal Engineer officers experienced in explosives.

THE PAY OF DRAUGHTSMEN.—The Ministry of Munitions having stated that it is prepared to sanction, on application by the employers, the payment of the 12½ per cent. to draughtsmen with an upstanding wage, it is now announced as a result of further correspondence between that department and the Association of Engineering and Shipbuilding Draughtsmen, that the 12½ per cent. is also to be applicable as follows:—"In cases where the emoluments exceed 250*l.* and do not exceed 500*l.* per annum, this department (Ministry of Munitions) would be prepared to consider the payment of a bonus on the first 250*l.*"

SOME NOTES ON AIR-LIFT PUMPS.*

By A. W. Purchas, of Wolverhampton, Associate Member.

(*Concluded from page* 563.)

Theory of the Air-Lift Pump.

This subject is here treated in the following sequence :

1. Design of air-injection foot-pieces.
2. Nature of the rate of change of velocity of the mixture in the eduction pipe.
3. Operation of the pump as a whole.
4. Submersion of the injection foot-piece.

Foot-pieces.—The design of the foot-piece does not play such an important part in the ultimate efficiency of the pump, provided :—

1. That the fundamental laws of the losses in transmission of air and water are carefully kept in mind, when designing ; and
2. That the air is injected into the water in the form of small bubbles.

Any attempt to use the injector principle is pure waste of time, and generally leads to throttled air and water passages, and a back pressure on the air of 2 lb. to 5 lb. per square inch, which represents so much wasted energy, for which no corresponding gain can be show elsewhere. This throttling effect is very marked in the tests by Messrs. Browne and Behr, which were made with a 1 in. diameter air-line terminating in a ¾-in. diameter nozzle. Some of the tests by Messrs. Davis and Weidner show the same fault.

Fig. 1 (page 561 *ante*) shows the foot-piece used by the author in the tests of Series A. Its obvious fault is the contracted water-passage, and its only excuse is its cheapness. The real reason that this was abandoned was the choking of the bottom of the air-pipe with rust and scale, so that eventually it caused an additional air pressure of 30 lb. per square inch. Alternate exposure to warm air and water will corrode steel at an extraordinary fast rate. Before putting the eduction pipe back into the well, after discovering this trouble, the "eddy cone" was removed, and Series B of tests was made with a foot-piece shown in Fig. 1a. The foot-piece shown in Fig. 2 was originally used in well No. 1, the aim being to inject the air in the form of small bubbles. This type suffered from the same faults as the previous ones. Series C of tests was made with the type shown in Fig. 2a.

When well 2 was last re-tubed, it seemed probable that the eduction pipe then inserted would be the largest ever required, and therefore full advantage was taken of previous experience and first cost was not so important. Fig. 3 shows the design of the resulting foot-piece, and this is the type used in Series D of tests. The following points were aimed at in the design :—

1. To avoid loss of air pressure in transmission from the well-head to the foot-piece, and keep the air pipe outside the eduction pipe without resorting to the use of the annular space around the outside of the eduction pipe. An air pipe run inside the eduction causes additional frictional losses in the rising mixture, with no corresponding gain elsewhere.

2. To provide a pocket to catch such scale and rust as may form in the air pipe, and thence fall into the foot-piece.

3. To introduce the air into the water in the form of small bubbles, as it has been claimed that the velocity of slip of an air bubble through water varies as the square root of its volume.† Since designing this foot piece, the author has found that Mr. Joseph P. Frizell, member Am. S.C.E., outlined the same type of foot piece in 1880, and in *Engineering News* of June 8, 1893, referring to the reverse process of compressing air by entanglement with falling water, wrote :—"This method was suggested by observing the very moderate velocity with which bubbles of air rise in still water, the velocity varying with the size of the bubble, from 9 in. per second or thereabouts for minute bubbles such as result from a slight agitation of the water, to as many feet per second in the case of great masses of air."

Mr. Kenneth Allen, describing the equipment and tests of the wells under his charge at Atlantic City, U.S.A., in a paper read before the Engineers' Club of Baltimore in 1908, also from his experience supports the same.

Mr. Edmund M. Ivens, on page 143 of his book, "Pumping by Compressed Air," writes :—"The small openings mentioned divide the air bulk into small streams and thoroughly aerate the column. Considerable gain in economy over other systems is realised thereby, as may be seen by comparison of the curves and tables."

4. To provide orifices for the air that would not corrode and choke up, as did those drilled in steel and used in the foot-piece shown in Fig. 1.

5. So to proportion the water passages that there should be no sudden change in the velocity of the rising column. The water passage at the bottom is 6 in. in diameter. From this point upwards the passage gradually contracts, and the water therefore is gradually accelerated until it reaches the bronze taper nipple. As the water rises through this, it is assumed that the air is uniformly admitted through the 120 ¼-in. holes, and that the velocity of the mixture is constant. Beyond this nipple the velocity of the mixture gradually increases until the size of the eduction pipe is increased.

6. To provide some form of guide on the lower end of the foot piece as shown in Fig. 1, to prevent its catching in the joints of the well casing when being lowered into the well.

* Paper read before the Institution of Mechanical Engineers, Friday, November 16, 1917.

† Compressed Air, by Professor Elmo G. Harris of the Missouri School of Mines.

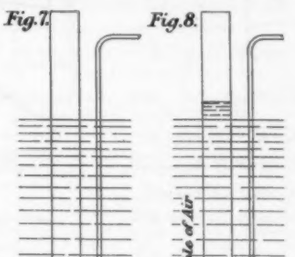
There is no necessity for the foot piece to be as long as that shown, unless it is so built as to form an auxiliary air-reservoir at this point ; a feature which has some advantages. It is equally possible to combine all the above points with the exception of No. 1 in a foot piece to be used on an air line inserted inside the eduction pipe, and this latter construction is sometimes necessary if the well casing be small.

Velocity of the Rising Mixture.—The air in the eduction pipe expands as it rises, due to the diminished head of liquid above it, and it may safely be assumed that it does so isothermally on account of the large volume of water by which it is surrounded. In the case of a single bubble of air rising through water, the pressure on the bubble will vary directly as the head of water above it. In an air-lift pump in operation the air bubbles are rising through a mixture of variable density, since the ratio by volume of air to water per foot length of eduction pipe increases as the outlet is approached. Under these conditions the pressure in the eduction pipe will vary as the ordinate to a hyperbolic curve, and the volume of each bubble as the ordinate to a straight line.

To find the volume of air passing any point in the eduction pipe per unit of time :—

Let P_1 be the absolute pressure of the atmosphere.
P_2 be the absolute pressure, equivalent to the head of submersion of the foot piece.
V_1 be the volume of air delivered per second to the pump, measured at pressure P_1, and a temperature equal to that of the liquid being pumped.
x be the distance of the point under consideration above the point of air injection in feet.
L be the distance in feet from the point of air injection vertically to the outlet of the eduction pipe.

The same weight of air, and likewise the same weight of water must pass each point of the eduction pipe per unit of time ; the volume of air flowing per second



through the outlet of the pump is V_1 cub. ft., and the volume of air entering the eduction pipe during the interval is $V_1 \frac{P_1}{P_2}$. The increase of volume of the air in ascending the eduction pipe is—

$$V_1 \left(1 - \frac{P_1}{P_2}\right),$$

and the total volume of air passing the point under consideration per unit of time is—

$$V_1 \frac{P_1}{P_2} + \frac{x}{L} V_1 \left(1 - \frac{P_1}{P_2}\right).$$

The sum of the volume of air and water passing per second being thus found and cross-sectional area of the pipe being known, the average velocity can be calculated. This average of what is in some cases a widely varying quantity, is the only value that can be calculated, and forms a very valuable deduction in analysing the results of tests and in designing the pipe for a new installation. In cases where the air is injected in the form of small bubbles, and the pump is run at or over its most economical capacity, the velocity at any point appears to remain fairly uniform, and as has been pointed out above, these conditions should exist in a well-designed pump ; therefore the average velocity calculated by the above method will be a close approximation to the true value.

Operation of the pump as a whole.—There are at least three different methods of approaching this question.

1. Which was enunciated by Dr. H. Lorens.* This takes account of friction and slip, but starts off with a "constant" which the tests by Messrs. Davis and Weidner showed to be as variable as any quantity can be. This theory is not reproduced here as it is cumbersome, and does not bring out the features of operation of the pump.

2. The second method,† the origin of which is uncertain, is based on the assumption that the motive power operating the pump is the difference of specific gravities of the mixture inside the eduction-pipe, and the liquid outside the pipe.

* "Zeitschrift des Vereines deutscher Ingenieure," Vol. 53, page 545, April, 1909.

† "Hydraulics," A. H. Gibson, page 702, 1912 edition.

Supposing L be the lift in feet ;
" S be the submersion in feet ;
" P_a be the absolute atmospheric pressure in lb. per square foot ;
" P_s be the absolute pressure of the air on leaving the injection foot-piece in lb. per square foot ;
" $\frac{V_m}{V_w}$ be the mean ratio of air to water by volume in the eduction-pipe at any instant of time.
" h_f be the friction head lost in the eduction-pipe, and at entry.
" h_s be the head lost by slip in the eduction-pipe.
" h_2 be the head equivalent to the velocity with which the mixture leaves the eduction pipe.

Then equating the pressure on the upper and lower sides of the horizontal plane of the air-injection foot piece :—

$$(L + S + h_f + h_s + h_2)\, 62.5\, \frac{V_w}{V_w + V_m} + \text{wt. of } V_m =$$
$$62.5\, S \text{ (for water)} \quad . \quad . \quad . \quad . \quad (1)$$

but since the weight of the air is negligible, this equation may be written :—

$$\frac{L + S + h_f + h_s + h_2}{S} = \frac{V_w + V_m}{V_w} \quad . \quad . \quad (2)$$

If now we consider V_w to be the volume of water pumped per minute, then V_m will be the volume of air required per minute, measured at some pressure P_m To find what this volume will be at atmospheric pressure we have the relation :—

$$V_m (P_s - P_a) = P_a V_a \log_e \frac{P_s}{P_a},$$

whence : $$V_m = V_a \left(\frac{P_a}{P_s - P_a}\right) \log_e \frac{P_s}{P_a},$$

substituting this value in equation (2) and solving, we obtain :—

$$\frac{V_a}{V_w} = \frac{L + h_f + h_s + h_2}{S \left(\frac{P_a}{P_s - P_a}\right) \log_e \frac{P_s}{P_a}},$$

in which V_a is the volume of air required, measured at atmospheric pressure, to raise the volume V_w of water.

A very plausible and common error in the above line of reasoning is to state that :—

$$P_m V_m = P_a V_a (1 + \log_e P_s) \div V_a,$$

and $P_m V_m = P_a V_a$,

therefore that—

$$V_m = \frac{V_a}{1 + \log_e \frac{P_s}{P_a}}.$$

A comparison of the formula obtained from this deduction with the equation given in the middle column of the next page will show the fallacy of the former.

3. This novel method of approaching the subject brings out better than either of the foregoing the details of operation of the process, and may be called the displacement theory. Fig. 7 (annexed) represents the pump prior to the injection of any air. Since the base of the eduction pipe is open, the pressures on both sides of the horizontal plane X — X are equal, and the liquid stands at the same height inside the pipe is outside.

Fig. 8 represents the conditions after a single bubble of air has been injected. The weight of this bubble of air is negligible when compared with an equal volume of liquid, and the bottom of the eduction pipe being open, the pressure on the two sides of the plane X — X will remain balanced ; therefore there must remain in the eduction pipe after the injection of the air the same volume of liquid as before. The liquid displaced by the air must therefore move upwards, raising the surface of the liquid inside the eduction pipe above that outside.

Let H be the amount of the rise,
V be the volume of the air bubble,
and A be the cross-sectional area of the eduction pipe.
Then

$$H = \frac{V}{A}.$$

The injection of the volume V of air has done work equal to ½ VH due to displacement alone, but the bubble will rise through the column of liquid, expanding as it does so and thereby increasing H. Neglecting friction, none of the energy originally contained in the air-bubble is lost until the bubble breaks the surface of the liquid and escapes into the atmosphere. When the air has finally escaped, then it may be said that the energy has been wasted in slip ; but not before.

Supposing the air to be injected into the eduction pipe at such rate that before the first bubble escapes to the atmosphere the total volume accumulated in the eduction pipe, say V_t is such that the head $\frac{V_t}{A}$ is greater than the lift L. Then the pump will discharge a volume of liquid equal to A (H — L). This is the volume that is violently discharged when an air lift pump is started up. The loss of this volume from the eduction pipe produces an unbalanced head, equal to H — L, on the plane X — X, which will force more water into the base of the pump. From this point onwards the operation of the pump may be regarded as a head H — L forcing liquid into that area of the eduction pipe, which is not already filled with air. Analysis of the published results of tests seems to show that the great loss in the pump is not by slip, but of this head H — L due to entry losses.

Tests yielding high efficiency always show either one

or both of the following features: low velocity of the rising mixture through the foot piece, or else a low ratio by volume of air to liquid at this point which is the result of great submersion. The effect of great relative submersion may however be offset in many existing wells by the relative high velocities of the mixture leaving the eduction pipe with consequent high friction losses. All of which suggests that the eduction pipe should be of as great cross-sectional area as the well permits from its base to at least the level from which the liquid is being raised. The loss by slip of this length is negligible, as we have seen, and the larger the pipe the less will be the loss of the head H — L. Above this point, however, the velocity of the rising mixture must lie between certain definite limits, otherwise the loss by slip will be excessive; therefore the area of the eduction pipe must bear a definite ratio to the volume of mixture flowing through it. What this ratio should be cannot definitely be stated on the data at present available, but it is hoped that the ideas here put forward may lead to more thorough tests being made of pumps in the future, and the publication of the results.

If the velocity with which the air bubbles will rise through the liquid can be calculated, then the total volume of air in the eduction pipe at any instant of time can be found from the known rate of injection. If this volume produces a head less than the lift, then with the submergence fixed, a greater rate of air supply must be used for the pump to deliver any liquid. If the rate of air supply is fixed, then a greater submergence must be provided, in which sufficient air can accumulate to produce the necessary head. A definite volume of air must be accumulated below the water surface inside the eduction pipe for the pump to work at all.

At the other extreme it is conceivable that the air could be injected at such high rate as to entirely hold back all liquid from entering the base of the eduction pipe, once the original contents were discharged. Such a state could hardly be obtained in any pump installation, but probably could be brought about with a 2-in. eduction pipe, 12-in. air pipe, and high rate of air supply. Experiments bear out these statements, for a series of tests on a pump at increasing rates of air supply show that below a certain rate there is no discharge. Above this point the discharge of liquid increases with the rate of air supply, and then begins to grow less as the rate of air supply is still further increased, Figs. 9, 10, 11.

This displacement theory also shows that the volume of air required to raise a given quantity of liquid is independent of the density of the liquid, if we neglect losses from friction and slip. However, the pressure equivalent to the required submersion and therefore the energy contained in the air injected, varies as the density of the liquid.

Submersion of the Air Injection Foot-Piece.

There is no rational formula known that will determine the most efficient value for the submersion, and only a few published tests touch on the point. Messrs. Davis and Weidner* made many small scale laboratory tests which are very inconclusive. Mr. Edmund Ivens, also records some tests on a large scale in his book, "Pumping by Compressed Air."

The displacement theory, already outlined, shows that the submerged portion of the eduction pipe is primarily necessary as an accumulator for the air. As will be seen later (*vide* next column), there is no such thing as a definite volume of air required to raise a given quantity of liquid to a given height, as the volume of air varies according to the submersion adopted. This conception of an accumulator for the air suggests that greater proportionate submersion is required for low lifts than for high, and that rather than bear a fixed ratio to the lift the most efficient value will bear a definite relation to the rate of air supply and cross-sectional area of the eduction pipe.

Current practice favours greater ratios of submergence to lift the lower the lift, and the following values are a fair average:—

Lift.	Ratio, Submersion. Lift.	Submersion.
Feet.		Feet.
25	4.00	100
50	3.00	150
75	2.33	175
100	2.00	200
150	1.70	255
200	1.38	275
250	1.22	305
300	1.00	300

Messrs. Davis and Weidner report as the result of 108 tests on a lift of 5 ft. with submergence varied from 30 to 88 per cent.:—"The efficiency increases as the percentage of submergence increases for all rates of input, and all practical percentages of submersion." It seems quite possible that a rational formula for determining the most efficient submergence may in time be developed from the displacement theory.

A Method of Designing Air-Lift Pumps.

To the designer who lacks the data which the larger manufacturers have accumulated, the following method is suggested:—

Let L be the lift in feet.
S be the submersion in feet.
V_w be the volume of water to be pumped per minute in cubic feet.
V_a be the volume of air required per minute measured at atmospheric pressure and a temperature equal to that of the water to be pumped.
P_a be the absolute pressure per square inch of the atmosphere.
P_s be the absolute pressure per square inch of the air under the submersion head S.

Then the energy supplied by the air to the water is:—

$$144\ P_a V_a \log_e \frac{P_s}{P_a} \text{ foot-pounds,}$$

and the work done on the water is $62.5\ V_w L$ ft.-lb.

Then, if the efficiency of the pump were 100 per cent. these two quantities would be equal. In order to apply this method, two assumptions must now be made, namely, the submersion and the efficiency of the pump.

Submersion.—A guide to the probable best value for this has been given already, and these values may be taken, though it will be seen later that they may need modification as the design proceeds.

Accepting these values, then—

$$P_s = P_a + 0.434\ S.$$

Efficiency of the Pump.—This at first seems a very rash assumption, but it is the author's belief that a careful study of this and other papers will show that it is not so. The following test figures stand out as the best so far reported, and analysis of other published tests shows no reason why they cannot always be duplicated:—

1. With the reverse process of compressing air by entanglement with falling water, an efficiency of 81 per cent. has been obtained in Germany,* and 71 per cent. at the plant of the Dominion Cotton Mills Company†, at Magog P.Q., Canada. This latter plant was the first installation designed on this principle.

2. Series D of tests at Oilfields show that an efficiency of 72 per cent. can be obtained with an air-lift pump on lifts of 300 ft., and an analysis of other published tests suggests that in each case higher efficiencies could have been obtained at other rates of working, or by modification of the designs along the lines already outlined. Furthermore, most writers on the subject have in the past conceded that higher efficiencies are obtainable on low lifts than on high lifts.

There is good ground, therefore, for assuming an efficiency of 70 per cent. for all lifts up to 300 ft. This may not be obtained with the first eduction pipe installed, but in the majority of cases the first eduction pipe is not the final one, but is installed to find the service pumping level and the capacity of the well. A series of tests made on the first pipe at varying rates of pumping should enable the above efficiency to be obtained with the final one.

These two assumptions being made, the volume of air and its initial pressure can be found from the formula:—

$$0.7 \times 144\ P_a V_a \log_e \frac{P_s}{P_a} = 62.5\ V_w L.$$

It must be borne in mind that the above volume of air is not the same as the displacement of the compressor piston. It is usually wise to have a reserve capacity in the compressor to cover such factors as encrusted eduction pipe, a demand for greater output of water, and wear of the compressor itself. The manufacturers should therefore be given the fullest details, since the power required to deliver any volume of air varies very widely with the speed of the compressor, and the ratio of the desired output to the full capacity of the machine. It may be noted here that high volumetric efficiency alone is not the desirable feature of a compressor, nor high mechanical efficiency alone, but the highest combination of the two. The best machine is that which will deliver the required volume of air at the given pressure with the least expenditure of energy in the prime mover. Some of the latest designs of air valves obtainable do not promise high volumetric efficiencies, but they conduce to high overall efficiency.

Reference to the tests in the tables, page 562 *ante*, will show that 40 per cent. of the energy generated by the prime mover may be wasted in the compressor itself, and therefore that as much attention should be paid to the choice of the air compressor as to the design of the eduction pipe and foot-piece.

Having finally determined the best value for the air-pressure, submersion and volume of air required, the air piping, foot-piece and eduction pipe can be designed. In proportioning the air pipe, allowance should be made for the temperature of the air leaving the compressor being high, and the volume therefore greater than would otherwise be the case. After making this allowance, the velocity of the air in the pipes should not be over 20 ft. per second. The design of a foot-piece has already been discussed, and will not be repeated here, neither the design of an eduction pipe along the lines suggested by the displacement theory. But to enable others to reproduce the design of which Series D of tests in the tables show the capabilities, the original calculations for this pump are here given:—

Assumptions and Conditions Based on previous Tests of the same Well.

Volume of water to be raised per second ... ... 0.50 cub. ft.

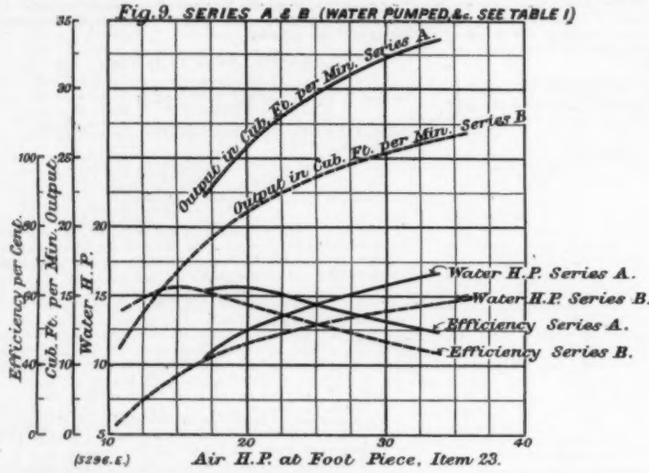
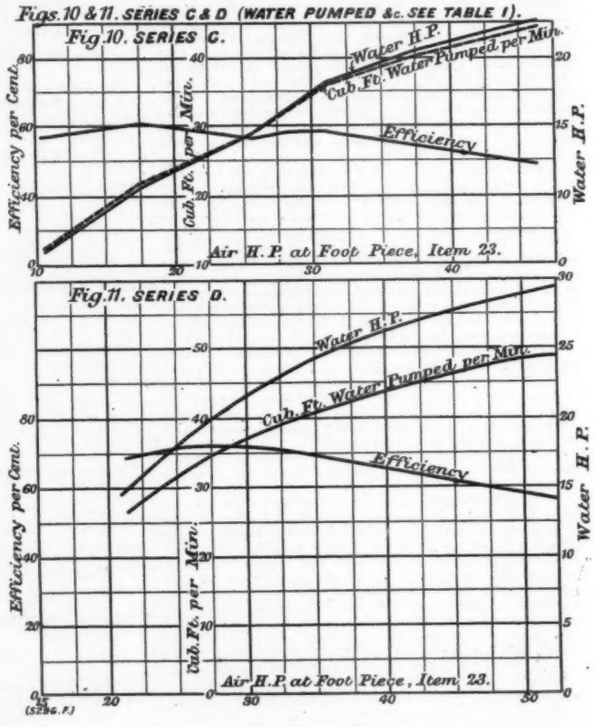


Fig. 9. SERIES A & B (WATER PUMPED &c. SEE TABLE I)
Output in Cub. Ft. per Min. Series A.
Output in Cub. Ft. per Min. Series B
Water H.P. Series A.
Water H.P. Series B.
Efficiency Series A.
Efficiency Series B.
Efficiency per Cent.
Cub. Ft. per Min. Output.
Water H.P.
Air H.P. at Foot Piece, Item 23.
(5296.E.)


Figs. 10 & 11. SERIES C & D (WATER PUMPED &c. SEE TABLE I).
Fig. 10. SERIES C.
Water H.P.
Cub. Ft. Water Pumped per Min.
Efficiency
Efficiency per Cent.
Cub. Ft. per Min.
Water H.P.
Air H.P. at Foot Piece, Item 23.
Fig. 11. SERIES D.
Water H.P.
Cub. Ft. Water Pumped per Min.
Efficiency
Efficiency per Cent.
Cub. Ft. per Min.
Water H.P.
Air H.P. at Foot Piece, Item 23.
(5296.F.)

* Bulletin, University of Wisconsin, U.S.A., No. 667.

* Dingler's Polytechnisches Journal, Vol. ccclxix, February 14, 1914.

† Trans., A.S.M.E., xxii, page 599.

Volume of air measured at atmospheric pressure and 70 deg. F. required per second	3.30 cub. ft.
Lift	300 ft.
Total length of eduction pipe ...	625 ft.
Velocity of rising mixture to be maintained, between	8 and 15 ft. per sec.

Air pipe to be kept outside eduction pipe.

Available pipe of suitable dimensions :—

Nominal Size.	Actual I. D. In.	Cross-Sectional Area. Sq. ft.
4-in. line pipe	4	0.087
$5\frac{3}{16}$-in. casing	5	0.136
$6\frac{3}{4}$-in. casing	$6\frac{1}{4}$	0.210

Calculations.—Pressure of air on leaving foot-piece—141-lb. gauge—3.30 cub. ft. of air at atmospheric pressure, and 70 deg. F., will be 0.308 cub. ft. at 141 lb. per square inch gauge pressure, and 70 deg. F.

The increase in volume of the air is 3.30 cub. ft. to 0.308 cub. ft. in a length of 625 ft. of eduction pipe, equivalent to 0.0048 cub. ft. per foot-length of pipe.

For a velocity of 15 ft. per second in 4-in. pipe, the volume flowing must be 1.305 cub. ft., which in this particular case will consist of 0.5 cub. ft. of water and 0.805 cub. ft. of air. If L be the feet of 4-in. pipe required between the foot-piece and its junction with the next larger size, then :—

$$0.805 = 0.308 + 0.0048\ L,$$

whence $L = 103$ ft.

In the next proposed size—$5\frac{3}{16}$-in. casing—a velocity of 15 ft. per second will require a volume of 2.10 cub. ft., which will be composed of 0.50 cub. ft. of water, and 1.60 cub. ft. of air. Calling the required length of 4-in. and $5\frac{3}{16}$-in. pipe combined L_1, then :—

$$1.60 = 0.308 + 0.0048\ L_1,$$

whence $L_1 = 270$ ft.,

and the length of $5\frac{3}{16}$ in. required is 167 ft.

Hence pipe desired is composed of :—

105 ft. of 4-in. line pipe.
167 ft. of $5\frac{3}{16}$-in. casing, and
355 ft. of $6\frac{3}{4}$-in. casing—a total length of 625 ft.

[NOTE.—$6\frac{3}{4}$-in. casing is the largest size pipe available which can be inserted alongside the air pipe in the well.]

Using the above lengths of pipe, the average velocity of the rising mixture will be :—

	Ft. per sec.
At foot-piece	9.3
,, top of 4-in. pipe	15.0
,, bottom of $5\frac{3}{16}$-in. pipe	9.3
,, top of $5\frac{3}{16}$-in. pipe	15.0
,, bottom of $6\frac{3}{4}$-in. pipe	10.0
,, top of $6\frac{3}{4}$-in. pipe	18.0

Conclusions.—Among the more important conclusions to be drawn which have not been previously emphasised, are the following :—

1. The apparent lack of agreement of different tests with any definite laws is due to two main causes : one, that the volume of air stated to have been used is too often the displacement of compressor piston, or too high a percentage of this, which introduces an error of 10 per cent. to 60 per cent. ; the other is the lack of segregation of the losses. For scientific purposes it is obviously useless to lump together the losses in the compression process and those in the eduction pipe. The former are fairly well understood, but the latter are quite unknown, and will remain so as long as only tests of the overall efficiency of installations are made. If the laws governing the losses in the pump proper are to be studied, then a test must give the energy contained in the air immediately after passing through the injection foot-piece.

2. That the greatest loss in an air-lift pumping installation is in the air compressor, and therefore that the best compressor is none too good for a permanent installation.

3. That the next greatest loss is the loss of head at entry. (For arguments in favour of this statement, see page 587.)

4. That any formula for calculating the submersion required would be better stated in the terms of "the volume of air used per second, at a pressure equivalent to the head of submersion," rather than in terms of the lift. This is suggested by the displacement theory of the submerged portion of the eduction pipe as a space for the air to accumulate and raise the water by displacement.

5. That every ounce of compression which the air is compressed above that pressure, which is equivalent to the submersion head, is so much energy wasted, and that attention should be paid to the design of the foot-piece and the air pipe with the object of reducing those losses to a minimum.

6. That a valuable item of information to include in the report of any test is the ratio of the volume of air to water at a point immediately above the foot-piece, and that the ratio by volume of air to water at the outlet of the pump is of little comparative value, since the volume of air is not a measure of the energy contained therein, unless the initial pressure is included in some form.

7. That the hotter the liquid to be pumped, the higher will be the efficiency of the pump. It has been shown by Professor Randall that an efficiency of 100 per cent. is possible under certain conditions when pumping water at 200 deg. F.

8. That many flowing oil wells are in reality "air-lift" pumps, using natural gas in place of air. Mr. A. T. Beazley, A.M.I.C.E., has obtained very encouraging success in making wells flow which had previously to be pumped, by applying to them the principles of the air-lift pump. The great obstacle to be overcome is the lack of control both of the quantity of gas and oil, and of the point of mingling of the two.

9. That considering the different forms of steam engines usually used in conjunction with different types of pumps, that the fuel consumption of an air-lift installation can be made to compare very favourably with that of any other type for raising liquid more than 75 ft. from a well. For shallow wells the employment of centrifugal pumps will probably prove more economical.

APPENDIX.—*List of References.*

To the student who wishes to search further into this matter, the following publications will be useful. They are given more or less in their order of usefulness, though some of them contain one or more of the common errors referred to in the body of the paper :—

"Compressed Air : Theory and Computations," by Elmo G. Harris, McGraw-Hill Book Company.

"An Investigation of the Air-Lift Pump," by George Jacob Davis and Carl Robert Weidner. Bulletin No. 667 of the University of Wisconsin, Madison, U.S.A. Price, 40 cents.

"Pumping by Compressed Air," by Edmund M. Ivens, Chapman and Hall, Limited.

ENGINEERING, November 13, 1903, pages 675 to 677, containing an account of Maxwell's tests at Tunbridge Wells.

Engineering News, June 8, 1893, pages 541 to 544, containing a very valuable history of the pump, its theory, and full details of the classic experiments by Messrs. Browne, Behr and Randall.

Engineering News, vol. lix, page 66, No. 3, January 16, 1908, containing an account of Mr. H. Tippor's experience as to conditions found in practice which makes one wonder that the pump ever found favour at all.

GAS FURNACES : THEIR DESIGN AND MANIPULATION.*

By ARTHUR FORSHAW, M.Sc., Chief Chemist to John Wright and Co., Birmingham.

(*Concluded from page 537.*)

HAVING spent a considerable time in dealing with furnaces for melting metal and their application, I must now turn your attention to another great branch of furnace work, viz., to furnaces for the heat-treatment of solid metals. This comprises open oven and closed muffle furnaces, and all the various operations that may be performed by their aid. In practice, the closed muffle, in which the products of combustion do not come in contact with the work, is relatively seldom used. It naturally requires a considerably larger amount of fuel to perform any operation in a muffle than in the corresponding open-oven furnace in which either the flame or the products of combustion pass over the work ; and therefore, unless there is some special reason for using a muffle, the oven is preferred.

The first types of oven-furnace consisted of a row of burners open to the air, the flames from which passed into the furnace and impinged on the underside of the furnace bottom (usually made of tiles), from thence passing along the tiles towards both sides of the furnace, and so round the edges of the tiles and into the working space. Exit from the working space was by way of flues in the arch of the furnace. The burners had usually natural draught. These furnaces were not very economical, as there was no direct control of the secondary air. If quicker heating or higher temperatures than those afforded by natural draught were required, air-blast burners were substituted ; but these were usually enclosed, and were introduced into the sides of the furnace alternately opposite each other with each flame directed into its own channel under the tiles. In some cases either natural draught or air-blast burners were introduced into the sides, and the flames entered above the furnace bottom. This was more often the case with air-blast burners.

Since then, much advance has been made in the direction of the control of the secondary air in natural-draught furnaces, and in that of preheating the air supply, as for instance, in our regenerative furnaces where the secondary air is controlled by dampers in front of the furnace, and is preheated by the hot brick-work before reaching the point of combustion. In some foreign-made furnaces, great efforts have been expended on suitably arranging the oncoming gas and air supplies with reference to the products of combustion or the hot radiating portions of the furnace exterior, in order to get the fullest advantage of recuperation. It has been found that the gap between natural-draught furnaces on the one hand, and those heated by air-blast on the other, could with advantage be filled in ; and for many purposes furnaces with air under slight pressure provided by a fan have been found satisfactory—thus avoiding the expense of the positive blower necessary for the pressure of 1 lb. to 3 lb. used with air-blast burners.

In our Lopress furnace we have developed this idea, and provided at the same time an effective example of recuperation. A novel feature of advantage in this type of furnace is that the gas is introduced and burned from the open ends of small pipes each controlled by a cock and attached to a large supply pipe. The flame thus produced is a luminous one. At a suitable point, air is introduced from similar jets and blows the luminous flame forward, either directly into the furnace and thence by flues under the bottom, or first through flues under the furnace floor and so into the furnace as may be most desirable, according to the work that has to be done. The air is supplied to the small jets from a large main or mains round which the products of combustion circulate on their way to the flue outlets. The air pressure required is in the neighbourhood of 6-in. water gauge for high temperatures.

The particular merits of this type are that it heats up more rapidly than the natural-draught type, and is more economical of gas. It only requires a fan for the air pressure, as against a positive blower for the air-blast type. It has a solid bottom with the flues built in, instead of tiles or slabs, and will consequently stand more hard work. But, most important of all, it enables any quality of flame to be obtained to suit the work in hand. It is the only gas furnace for instance, where the "greasy" flame so necessary to prevent scaling can be satisfactorily ensured—a flame such as one sees in ovens heated by bituminous slack. This is invaluable in heating work where scaling is inadmissible or must be reduced to a minimum.

There are several points about design in oven furnaces to which I should like to direct your attention. In the heating-up of material, the three modes of transference of heat all have their part. Take the case of a flat plate of iron laid on the bottom of a furnace heated by burners under the floor slab. The upper side of it is heated by radiation from the roof or arch and from the walls. It is also heated by the impingement on it of flame or products of combustion ; while the underside is heated by conduction, and by radiation from the slab. It will, therefore, be heated rapidly and equally all over. In the further case of a number of flat plates placed on the top of one another, or a number of bars or tubes piled up, it is clear that the furnace will require as much bottom heat as possible ; otherwise the whole of the material except the top layer must be heated by conduction from that layer, with the result that the top layers are overdone before the bottom layers are more than warm. For reasons of this sort, there are few cases in which we find it advisable to recommend a furnace having a solid bottom, and heated directly by burners placed in the upper part of the furnace. As a matter of figures, it is possible in a space so heated to attain a given temperature with approximately half as much gas as in one heated below the slab. But more demonstration advantages such as this are of no actual benefit, because if a furnace is not suitable for the work the furnace in particular, and gas-heating in general, quite undeservedly suffer in reputation.

Let us now consider for a short time the different operations to which oven furnaces are adapted. First, we will treat of annealing. This is a term sometimes used to express different operations, though usually it means a heat treatment applied to metals that have been mechanically worked in some way—for instance, hammered, bent, drawn, or rolled—or to metals, like steel, that have been hardened by quick cooling from high temperatures. It means heating them up and cooling them slowly through certain critical temperatures. This mechanical working usually gives a product in which there is internal strain of some sort, resulting in inability to stand further stress, or in a tendency to revert to a previous form.

A very good example of this is the production of cartridge cases. The cast ingot is passed through rolls which perform the "breaking-down" operation as it is called—the ingot is increased in length and decreased in thickness. After the first rolling, it is still much thicker than is required for blanking. But before anything further may be done to reduce it, the metal must be annealed ; otherwise it would crack or break under the next operation. After annealing it may with safety be rolled again ; but it must be annealed several times in all before it finally arrives at the correct thickness for blanking, *i.e.*, punching-out the blanks from which the individual cases are made. Again, during the drawing processes by which the blank is caused to assume the shape of the finished case, several annealings must be carried out. If the correct number of annealings is not carried out, the finished product is in a state of molecular strain, with the result that eventually it cracks. This result of the effort on the part of the metal to return to a state of internal equilibrium may not show itself for some months and is known as season cracking. We have had experience of cases of it in solid-drawn brass tubes which have been in use for some time ; while it has been known to occur in cartridge cases after they have been stored between six and twelve months.

The importance of the particular temperature at which annealing is performed calls for mention. Some important experimental work has been done by Charpy on brasses, and among them this same alloy—viz., 70/30 brass. In its natural state it has a tensile strength of about 18 tons per square inch. He found that after hammering and rolling sufficiently, this is increased to a maximum of about 32 tons. The annealing experiments showed that up to about 300 deg. C. there was very little effect on the metal ; but above this temperature, and up to 600deg. C., there was a gradually increased softening. At the latter temperature the tensile strength had dropped to about 17 tons per square inch, after which it remained about constant up to 850 deg. C. ; above 900 deg. C. it became over-annealed or burnt.

Of course, usually speaking, the annealing of steel is a more interesting subject than that of non-ferrous metals. In order to follow the annealing and heat-treatment generally of steel, some knowledge of the composition, both chemical and structural, is necessary. To give a detailed account of such a subject as the micro-structure of steel would require, however, all the

* Paper read before the Manchester District Junior Gas Association, November 3, 1917.

time at my disposal, and therefore cannot be attempted. Still, such a slight idea may be given as will help the changes in steels by heat-treatment to be intelligently followed by those who have not made a study of it.

Ordinary steels may be roughly defined as alloys of iron and carbon. Steel—that is, iron containing carbon—exists in several different forms; and the heat treatment of steel is mainly concerned in ensuring that we shall obtain the particular form of alloy that we require. True steel—in which I am not including for the moment the special alloys containing nickel, chromium, tungsten, vanadium, &c., which are also classed under the name steel—can be forged and welded, and can be hardened and tempered by heating and sudden cooling, or softened and toughened by heating and slow cooling. As the percentage of carbon decreases, so does the property of hardening, and at about 0.2 per cent. it is practically nil; while as the carbon increases, the welding property and the forging property decrease, till at 1.2 per cent. of carbon steel is not weldable by ordinary shop methods, and at 2 per cent. it cannot be forged. The ordinary steels then contain somewhere between 0.2 per cent. and 1.5 per cent. of carbon. If such steels, containing up to 0.9 per cent. of carbon be slowly cooled after solidification, they exist above 890 deg. C. as practically homogeneous solid solutions of carbon in iron. This form may be rendered permanent by sudden cooling, and is known as martensite. Below 700 deg. C. slowly-cooled iron is incapable of retaining carbon in solid solution. The carbon therefore separates out in the form of the carbide of iron (Fe_3C), known as cementite; the iron not used up to form this compound being left pure, and called ferrite.

To make the story complete, ferrite and cementite form a further alloy (21 Fe + Fe_3C), known from its appearance under the microscope as the pearlite eutectoid, which persists in the cold steel. As this eutectoid contains about 0.9 per cent. of carbon, it is obvious that a slowly-cooled steel containing 0.9 per cent. of carbon will consist wholly of pearlite; while below 0.9 per cent. of carbon it will consist of a mixture of ferrite and pearlite, and above this percentage of a mixture of cementite and pearlite. As revealed by the microscope, pearlite consists of a number of thin plates of ferrite and cementite alternating in sandwich fashion. On cooling slowly—between 890 deg. and 700 deg.—changes take place. In steels up to 0.9 per cent. of carbon, the whole mass ceases to be homogeneous solid solution of carbon in iron, and gradually separates into a mixture of solid solution and pure iron—the carbon, as seen under the microscope, is found to be concentrated in those parts consisting of solid solution; while the other parts, being pure iron, contain no carbon. To put it in another way, the area of martensite becomes less, while the area of ferrite grows. As the percentage of carbon in the steel, as a whole, increases, the temperature at which this change starts is lowered, so that with 0.45 per cent. of carbon, instead of occurring at 890 deg., it occurs at 760 deg. All the same, when 700 deg. is reached the solid solution of carbon—*i.e.*, martensite—cannot persist, and the carbon, as already described, is separated out as the compound iron carbide (Fe_3C), cementite.

So far we have been considering steel containing up to 0.9 per cent. of carbon. Now let us glance at the steels containing above 0.9 per cent. and up to 1.5 per cent.—the upper limit of carbon which we took for our purpose. Above 950 deg. the steel exists as before in the form of solid solution of carbon in iron—martensite. As it cools, however, there is more carbon present than can be retained in solution, so that some of the carbon combines with the iron and forms cementite. This commences at approximately 950 deg. C. in steel containing 1.5 per cent. of carbon, and as the temperature drops, the cementite increases. The lower the total carbon the lower the temperature at which the cementite begins to form. When 700 deg. C. is reached, the martensite cannot persist, and splits up into cementite and pearlite, as already decribed. The first important point to notice is that, whatever the percentage of carbon, all steels above 700 deg. C. contain martensite; and it is this constituent which is characteristic of hard steels that have been quenched above, say, 760 deg. C. The second point is that, slowly cooled to below 700 deg. C., all steels contain cementite. Cementite is in itself an extremely hard substance, and withal brittle. In annealed steels below 0.9 per cent. of carbon it exists, as already mentioned in conjunction with ferrite as pearlite, and also surrounded by more or less free ferrite. Ferrite, however, is tough and soft, so that the lower the percentage of carbon the tougher and less brittle is the steel. Even at 0.9 per cent. of carbon, where the whole mass consists of pearlite, the ferrite layers in this give it a certain amount of toughness. As 1 per cent. of carbon is exceeded, free cementite becomes greater in proportion, so that the steels become naturally harder, but more brittle from the progressively smaller amounts of pearlite, and therefore of ferrite, which they contain. With these facts in mind, we are able to appreciate the changes that occur in annealing, hardening, tempering and case-hardening, and at the same time understand why tools for different uses require higher or lower percentages of carbon in them.

A steel that has been overheated and allowed to cool slowly, without being worked, is composed of large crystals—its structure is coarse, and it is very fragile. This steel can be restored to a useful condition by heating to a good heat and forging down to dull redness; but even then it is not in an ideal state. This is particularly the case in forging articles of irregular shape which are subject to the defects of irregular extension and cooling and of cold working; while some parts may be of coarse structure owing to insufficient forging. In addition to this, during the machining of already annealed steel, stresses are often set up which would probably cause cracking or breaking in subsequent operations. Annealing is resorted to as a cure for all these defects; and the procedure to be adopted is as follows: The steel is heated up until the ferrite and pearlite or the cementite and pearlite, as the case may be, start to diffuse into one another, with the formation of martensite. This is the opposite effect from that mentioned when describing the cooling down of steel. Brearley gives the following temperatures for steels containing different amounts of carbon as those at which the change will take place:—

Percentage Carbon in Steel.	Lowest Temperature to which Steel must be Heated. Deg. C.
0.2	870
0.4	810
0.6	780
0.9	750
1.1	830
1.3	890

He adds that 20 deg. to 30 deg. above these temperatures causes no ill-effect; but the exposure must be a short one. When the heating has been finished, the metal is cooled down uniformly in the furnace until it is under visible redness, after which, as rapid cooling has then no effect on it, it may be cooled down to normal temperature as rapidly as convenient.

The usual object of annealing, apart from curing the defects mentioned above, is to render the steel as soft as possible for machining purposes; and it may entail softening steel which has already been hardened by quenching. In such cases, the steel is most quickly softened by reheating to within a few degrees of the hardening temperature, and then cooling in air. If this particular temperature is exceeded, however, the steel would, on cooling in air, be harder. This is illustrated by the following table (after Brearley), showing the Brinell hardness number on reheating to various temperatures of a quenched steel containing 1 per cent. of carbon:—

Reheated to Deg. C.	Hardness—Air-cooled.	Hardness—Quenched in Water.
500	320	320
600	240	240
720	187	187
725	170	187
750	196	555
850	241	555
950	269	555

On the other hand, for thorough softening, the steel is heated to a temperature a little above the hardening point, and is allowed to cool slowly in the furnace. Some authorities consider that the former or quick method, while not giving so soft a steel as the latter, is yet preferable in some respects, as it gives a product that machines more sweetly. It will be readily understood how peculiarly gas-heated annealing furnaces lend themselves to the carrying out of operations of the kind I have been describing, affording as they do in an unequalled degree that ease and exactitude of regulation which are so essential.

The above table also gives us some idea of what is meant by hardening, and more need not be said about it than that water is not the only quenching medium—indeed, in many instances, oil, or preferably salt, baths are used for the purpose, as being less severe in their action than water. As a matter of fact, the hardening effect depends upon the rapidity with which the steel is cooled through the critical temperature, and it is in all cases completed by the time the whole body of the metal has arrived at 680 deg.

Baths consisting of fused salts, metals, or alloys are used for hardening, provided their temperature is low enough. This proviso has, in the past, practically excluded the use of simple salts or metals for the purpose of quenching, as there are very few simple salts, and no cheap ones, with a sufficiently low fusing-point. Fusible metallic alloys, which melt at a temperature below the boiling point of water, have been tried and found unsuitable. We have, however, recently developed the use of a substance called "quenchite," which at ordinary temperatures is a white solid, but which is liquid at a temperature of 140 deg. C. It might be supposed that a liquid at such a temperature, well above the boiling-point of water, would not harden carbon steel successfully. But the fact is that quenchite has a very powerful quenching action, mainly because its boiling-point, being above 800 deg. C., does not form steam or vapour when the steel is plunged into it, and it retains close contact with the steel, and extracts the heat from it very rapidly, which it could not do if the article were protected by a jacket of steam or vapour. Tools are rendered glass-hard by the use of quenchite; while the risk of cracking or warping is reduced to a minimum, as the temperature is sufficiently high to give rise to a distinct tempering action. Quenchite baths of various sizes heated by gas are in regular use in many engineering works.

After hardening, all tools are usually tempered—that is, heated to a definite temperature. There are many ways of doing this; but the best is to immerse them in a liquid bath of some sort. The object of this is to give the tool or metal sufficient toughness to withstand the shocks to which it is put during the work it has to do—the temperature at which the operation is carried out varies from 150 deg. C. to about 300 deg. or over. It was usual to heat the tool in air until it showed a certain surface colour due to oxidation; but modern practice finds it more satisfactory to heat to a definite temperature in a liquid bath. It is practically certain that the attainment of the exact "temper" is a function of temperature, while it has also been proved that the different surface colours can be obtained at various temperatures according to the length of time the metal is exposed. The liquid bath (salts, oil, or metal) has the further advantage that the whole of the article can be heated up to the same uniform temperature; while tools like files or drills, which require local tempering or softening in the tangs or shanks, are commonly dealt with by dipping these parts only in lead baths. In many cases our mixture of salts, known as "Feusalt," is used for tempering articles which require a higher temperature than can safely be applied to oil. Tempering processes frequently demand considerable accuracy; and a "Feusalt" bath heated by gas is an ideal arrangement for such work.

We now have briefly to consider case-hardening. This is a process whereby mild steel is caused to have a very hard surface to withstand wear, while the core of the article remains tough and soft. The metal to be treated, such as a camshaft or a gudgeon-pin, is packed in a box with carbonaceous material like charcoal or yellow prussiate of potash, carbonised leather, or the like. The temperature is then raised gradually to about 900 deg. C. The length of time during which the metal is subject to the action of the carbon determines the depth to which the latter is able to penetrate. The temperature determines the rate at which penetration proceeds—usually this is about one-hundredth of an inch per hour. During the casing process great care has to be taken to get the furnace evenly heated, because otherwise—as will be recognised—the case will not be of equal thickness all over the objects treated. After this treatment, the internal core is often in an undesirable state, due to the prolonged heating. This may be remedied in more than one way. For instance, many articles are quenched in oil direct from the hardening boxes. This leaves the core in good condition and, prevents the formation of crystals during the cooling; but it is bad for the case. The articles are accordingly reheated to about 760 deg. C., and again quenched—this time either in water or oil. The second heating does not injure the core, which has already been satisfactorily dealt with; but it greatly improves the "case," rendering it very hard, and close grained.

Another treatment consists in allowing the articles to cool in the box. They are then withdrawn from the box, reheated to about 820 deg. C., to deal with the core, and quenched in water. Subsequently they are reheated a second time to 765 deg. C., and again quenched in water, to get the case into the desired condition. The reheating of carburised work is best done in baths containing "Pyromelt." The "Pyromelt" leaves the surface of the articles, after quenching, glass-hard, and work so treated is in the best condition, because the temperature can be regulated to a nicety; also no part of the article can fail to be heated up to the right temperature, and no part can possibly be overheated. Large numbers of gas-heated salt baths are in regular use for the reheating of carburised work.

Heat treatments are carried out in oven furnaces for a variety of purposes not included in the above. For instance, perhaps the latest we have designed is in connection with cast-iron fuse caps. When made of this material, it is necessary to put the fuses through some process to prevent them from subsequently rusting. Of our two apparatus for this purpose, the non-automatic form for this consists of an oven furnace in which the fuses, mounted on trays each containing 50, are heated and then quenched in cotton-seed oil. This gives the fuse a rust-proof black surface. The temperature must be within the limits of 650 deg. and 700 deg. C. Below 650 deg. the fuses would not take the surface; while above 700 deg. growth of the cast-iron commences and prevents the fuses passing the subsequent strict gauging tests. In our automatic apparatus the fuses are placed one by one on holders which are passed through an oven furnace by an endless chain. At the outlet end they are automatically quenched in the oil and drop on to a conveyor which bring them out from the oil again. I only mention this particular process because it is practically a new one. The ordinary processes of heat-treating war material like cartridge cases, cartridge clips, bayonets, digging tools, and the many other articles in general have been frequently described. They all fall under one or other of the processes I have already described under annealing, hardening, &c.

Before leaving oven furnaces, I should like to give a few points concerning their care and manipulation. Generally speaking, they are not called upon to stand such high temperatures as crucible furnaces; and may be expected that the walls and arch will last an indefinite time. The place where wear shows itself soonest is, of course, the bottom, where heavy weights are often placed. When the bottom is of slabs or tiles and heated from underneath, it will be seen that breakage can easily occur; and this consideration has led to many furnaces being built with solid bottoms containing flues, such as the "Lopress" furnace already referred to. Another thing to watch for is the dropping of scale or slag on the brickwork. This is always occurring; and it is as well to get rid of these materials at regular intervals.

Usually an oven furnace is built with the working space bounded by upright tiles or bricks. These prevent much scale getting into the combustion space below the slab. If these tiles are absent, the bottom slabs should be periodically removed, or an accumulation of such material may block the combustion space, or the burners, and interfere with the working of the oven. In the manipulation it is a good plan to work with as little primary and secondary air as the operation will permit. An intelligent use of the primary and secondary air sleeves and of the flue dampers will enable the user to save much gas. I have seen, in a oven fitted with a pyrometer, where the temperature was running constant, a difference of 100 deg. C. either caused by slight manipulation of the air and flue dampers above. One

cannot give exact directions. The correct manipulation will be found after experience, and depends on the temperature desired, the work to be done, the pressure of the gas, and so forth. In general, it may be said that sufficient advantage is not taken of the regulators provided. In all furnaces, but particularly for exact work like case-hardening, it is a great advantage to fit a gas governor.

Another point in connection with the saving of gas may be mentioned. Some years ago we carried out a series of experiments on the heat insulation of furnaces, and as a result we were able to reduce the heat lost by radiation and convection very materially; but every user can increase the insulation for himself by spreading the outside of the furnace with any of the usual insulators. In this way he not only saves gas, but promotes the comfort of the workmen.

Before leaving the consideration of oven furnaces, I feel it necessary to mention those used in the hardening of high-speed steel. The whole subject of these special steels is of great interest, and is by no means in the comparatively explored and settled state of the carbon steels. The properties expected from high-speed steel are those of hardness and resistance to the softening effect of heat. A turning tool, for instance, will cut mild steel at such a rate that its point is raised to a temperature of 500 deg. to 600 deg. C. without softening. The ability to perform work of this sort depends first on the composition of the tool and then on the heat-treatment to which it has been subjected. When heated to 900 deg. to 950 deg. C. and quenched in oil, high-speed steel is quite hard; but it is not possessed of "red-hardness"—viz., the characteristic property of high-speed steel, of cutting mild steel at high speeds for a long time. This can only be ensured by the correct heat-treatment.

In the first place, the tool is presumed to be in the annealed state. It is then hardened from a high temperature—say, between 1,200 deg. and 1,300 deg. C. At this temperature, which varies slightly for each particular brand of steel, the formation of a double carbide of chromium and tungsten dissolved in the iron is supposed by some authorities to take place. It is not good practice to heat the steel directly from cold to this high temperature, on account of the tendency to crack. In the furnace we specially designed for the purpose of hardening high-speed steel, we provide two chambers. One is heated directly by a powerful burner to a temperature rather above that at which the solution of the mixed carbides occurs; the other, or preheating chamber, heated by the waste products from the first, attains a temperature of 800 deg. to 900 deg. The tool is first placed in the preheater and raised to redness. It is then transferred to the hot chamber and rapidly heated. When the change takes place in the constitution of the steel, it absorbs heat and appears to be slightly darker in colour for a short time. As the change is complete, the tool visibly rises in temperature again, starting with the thinner parts. When uniformly hot, it is removed from the furnace and often cooled in an air-blast or quenched in oil; but we prefer to quench in "Feusalt," at a temperature of about 230 deg. C.

"Feusalt" has already been referred to as in use for tempering; but it has a very wide application for quenching high-speed steel. The particular advantage is that the tool is cooled much more swiftly than in cold air, and yet the risk of cracking is much reduced, for when the quenching in "Feusalt" is complete the temperature is still so high that the strains are relieved, and the tool has time to adjust itself to the new conditions. The uniformity of cooling in a bath of "Feusalt" is very advantageous in comparison with the irregular cooling in an air-blast—the air-blast chills the sharp corners and outer portions of the tool, while other parts are still red hot. Under the action of an air-blast the different parts of a circular tool—for instance, the outside circumference of the hole—may vary in temperature by hundreds of degrees for some length of time; but in a bath of "Feusalt" they are very quickly brought to the same temperature. For this and other reasons high-speed tools quenched in "Feusalt" are much better than those cooled in an air-blast.

I have so far dealt with the furnaces in general use, and the work they are put to. When one considers special furnaces that have been made, one is astounded at the numerous possibilities for employing gas. It is, however, impossible for me to deal with this side of gas heating at present; it would require a paper to itself. I cannot, however, miss this opportunity of saying something on the subject of coal-gas itself, as suggested by the experience we have gained in gas-furnace matters. When I last addressed this association, I laid special emphasis on the view—which, indeed, we have long held and frequently expressed—as to the need for uniformity in the quality of gas supplied by the gas undertakings; and I described the difficulties of the gas-heating engineer owing to the wide diversity shown in different parts of the country in such matters as pressure, calorific value, composition due to the various qualities of coals, thermal treatments, percentage of water-gas, &c. That need of uniformity is as great to-day as it was then, and in some respects it is more acute. The ground, however, has shifted somewhat.

Owing to the present circumstances, calorific value has, on the whole, tended to become more uniform. Gas engineers have had to be content with what they could get in the way of supplies of material; and there has been a general tendency for the higher calorific values to drop. But while any movement towards uniformity in this direction is to be welcomed, it is necessary that it should not take place at the expense of uniformity in other directions. At the risk of repeating arguments with which you may be familiar, I must say that we, as gas-heating engineers, cannot look with equanimity on the reduction of calorific value if it is brought about by dilution with inert gases, nor do we welcome continually-varying percentages of water-gas or high specific gravities. It is highly important in many gas-furnace operations that a high flame temperature should be attained. As the percentage of incombustibles rises, this property is impaired. Again water-gas requires, volume for volume, less air than the coal-gas it replaces. A sudden jump from, say, 10 per cent. to 35 per cent. of water-gas—a not unknown happening—has a very considerable effect on a flame that has been set for the former percentage. Generally speaking, we do not mind low calorific value—we have melted much metal by blue water-gas alone; but we do ask you, as gas engineers, to assist us in the matter of flame temperature, unfluctuating pressure, and unvarying percentages of constituents likely to upset flame quality, and as far as possible to standardise the chief product of the gas works, so that, in whatever part of the country it may be, a reasonably constant quality of gas can be counted on. This is not merely a selfish request on our part. The essence of cheapness is standardisation and the consequent output it allows; and uniformity in gas quality promotes standardisation in apparatus, and so favours increase of output and cheapness.

Important as the question of standardisation of gas is from our point of view, in closing I must direct your attention to a more serious side of it from your point of view. You, as gas engineers, are trying to create and maintain a large output of coal-gas for industrial purposes. The war, with its unparalleled call for explosives and for munitions, has enabled your output to increase by leaps and bounds. What will happen to that increased output when the war is over? I would urge that you supply a standardised product at a price that can compete favourably with rivals like solid fuel, water-gas, and producer gas, otherwise the present rate of increasing gas output—on the furnace side at any rate (which I would point out is mainly due to the war)—cannot be expected to go on increasing, once the war is over, but will receive a check. I speak with knowledge when I say that the demand for these three alternative fuels is an insistent and increasing one. I hope I have said enough to indicate the great opportunity which, in my opinion, lies in front of the gas undertakings, and to show that the future of industrial coal-gas furnaces depends to a large extent on their policy in the next few years. If I have in any degree made these points clear, I shall have so far fulfilled the purpose of this paper.

To my various colleagues associated with the firm of John Wright and Co.—the results of whose chemical and technical work, along with my own, is embodied in this paper—I desire to express my acknowledgments, as well as to the company itself, for permission to avail myself of the records of this work in the preparation of the paper.

THE INSTITUTE OF ARBITRATORS.—At the annual meeting of the Institute of Arbitrators, held at Winchester House, Old Broad-street, E.C, on November 20, Mr. Henry Adams, M.Inst.C.E., M.I.Mech.E., F.S.I., &c. was unanimously elected as president, and Mr. H. D. Searles-Wood, F.R.I.B.A., &c., vice-president; the retiring members of council, Messrs. Walter Lawrance, F.S.I., T.E. Bare, M.Q.S.A., and E. J. Sadgrove, F.R.I.B.A., M.S.A., were re-elected.

A SIMPLE X-RAY BULB FOR PHYSICAL RESEARCH.—The X-ray bulb which Dr. H. Rausch von Traubenberg uses for research work, and of which Debye and Scherrer made use in their remarkable investigations of the structure of crystals and powders, is a pear-shaped glass bulb, which is provided with a metal cap or collar at the narrow end (*Physikalische Zeitschrift*, June 1, 1917). This collar of brass is simply fixed by means of sealing-wax. From the cap rises a brass tube into the side of which an aluminium window, 0.05 mm. in thickness, is fitted. Above the window the tube opens out a little to receive another tube, which is ground into the former; to this latter tube the antikathode is fixed obliquely, so as to be opposite the window and above the kathode, which is in the lower portion of the bulb. All these parts are kept cool by water circulating through smaller tubes, and the brass tube is permanently connected with a Gaede pump to maintain the vacuum. One of the advantages claimed for this construction is that the antikathode can easily be replaced by one of a different material when rays of a different degree of hardness are required.

AMERICAN AEROPLANES.—According to *The Iron Age*, New York, contracts have been let, and work is in progress on practically the entire number of aeroplanes and motors for which provision was made in the 640,000,000 dols. Aviation Bill passed by Congress in July. This programme called for over 20,000 aeroplanes. The types of aeroplanes now in process of manufacture cover the entire range of training machines, light high-speed fighting machines, and powerful battle and bombing planes of the heaviest design, of the Caproni, Handley Page, and similar types. Every measure has been taken to insure that the American forces in France be amply equipped with aircraft. The work of the aviation section has been thoroughly systematised. The training of aviators, the building of motors and the construction of wings are proceeding uniformly, each keeping pace with the other and with general war plans. Co-ordination has been developed in every branch of the aviation section. Under the direction of the Aircraft Production Board, there is being accomplished an international standardisation in the tests of materials and their specifications, so that through a unification of the demands upon the United States there may be full use of American resources.

CATALOGUES.

Electric Wiring Fittings.—Messrs. Pass and Seymour, Solvay, New York, send a large 80-page catalogue of small fittings for electric wiring. There are hundreds of items in sockets, adapters, switches, &c., all carefully numbered and sized and illustrated.

Non-skid Tyre Shoes.—Messrs. Brown Brothers, Limited, Great Eastern-street, London, E.C. 2, send a catalogue of the "Brook" supplementary tread for double-tyred wheels. A series of malleable-iron shoes are connected chainwise round the tyres, each shoe having a tongue which fits between the two tyres and a tread which overlaps both tyres. They are easily put on or off, and weigh about 43 lb. for a 36-in. wheel.

Heating Stoves.—Messrs. Smith and Wellstood, Limited, Bonnybridge, Stirlingshire, send an illustration, with list of sizes and prices, of substantial cast-iron stove, for warming factories. All are of circular sections 16 in. in diameter, and in six sizes, from 32 in. to 49 in. in height, suitable for warming spaces of 10,000 cub. ft. to 20,000 cub. ft. These are fit for anthracite fuel.

Direct-Current Motors.—A series of small motors for continuous electric current, of powers ranging from 0.15 h.p. to 10 h.p., are shown in a special catalogue issued by the British Thomson-Houston Company, Limited, Rugby. The construction is fully and clearly described, with the various special adaptations. Dimensions, weights, and pulley and pinion sizes are also given in clear tabular form.

Chemical Works Machinery.—Messrs. Meldrums, Limited, Timperley, near Manchester, send a leaflet catalogue showing a still with stirrer, a 250-gallon mixing pan with steam jacket and agitator, a vessel called an acid egg of 300 gallons capacity and suitable for 50 lb. pressure, and a series of ejectors and elevators for air, water and acids, made of cast-iron or metals specially suitable for acids.

Electric Current Converters.—The British Westinghouse Company, Limited, Trafford-park, Manchester, has issued a 60-page pamphlet of instructions for using their rotary converters. It gives a description of the machines, and then deals with the subjects of unpacking, drying, erecting, testing insulation, breakdown test, adjustments, operation, starting, care of bearings, lubrication, truing commutators in place by grinding, undercutting mica, and general repairs. The book will be useful to those, especially, who have charge of such plant, but are not wholly experts in the care of it.

Electric Disconnectors.—Messrs. George Ellison, Perry Barr, Birmingham, send a catalogue giving very full and precise particulars of disconnectors which may be easily applied to any part of a circuit. They are especially intended for branch lines of a factory system, to allow small sections or single motors to be readily isolated for repairs or alterations without causing an extensive stoppage. They are supplied for alternating or direct current up to 750 volts, for bolting to a wall or on a stand with oil circuit breaker, or with circuit breaker and oil starter.

Small Milling Machine.—Messrs. W. A. Walber and Co., 38, Victoria-street, London, S.W., send a catalogue describing a "hand milling machine." It is a small machine driven by power, with hand feeds, and specially intended for tool-room use and odd jobs. The feed travels are 9 in. long way, 3¼ in. crossway, and 5 in. vertically. The supplementary fittings supplied, if required, are: overhanging arm, attachable vertical spindle mill, dividing heads, swivelling table for milling tapers, cast-iron pedestal. The feed on the plain table is by lever or screw, but a power screw feed can be fitted if desired.

American Export Organisation.—A catalogue containing an outline of the arrangements for organising the export of American engineering products comes from the American Steel Export Company, Woolworth Buildings, New York. The company proposes to deal with all foreign inquiries for buildings and plant, especially for complete mechanical equipments of mines, quarries, foundries, sawmills, machine shops, manufactories, railways, docks, &c. The idea is that buyers do not always know precisely what they want, that makers are often unable to prepare proposals really suitable to the local conditions of the foreign market, and that the company should provide a staff of experts to remedy both these deficiencies. The company would also make inquiries as to the standing of foreign buyers and do all the work of agents on behalf of a great combination of American exporters. The scheme is ambitious, and no names are given of either individuals or firms by which we can judge of its prospects of success. It is, however, a well-planned and well organised attempt to put into practice methods of national co-operation in promoting foreign trade which have often been discussed.

GROWTH OF RAILWAY TRAFFIC IN THE UNITED STATES.—With only a small increase in the number of miles of line, locomotives and cars, the traffic for the calendar year 1917, says *The Railway Mechanical Engineer*, New York, promises to be 52 per cent. greater than for that of the fiscal year ended June 30, 1915. This increase of 140,000,000,000 ton miles is equivalent to the total traffic moved annually before the war by the following 14 countries:—Germany, France, Russia, Spain, Sweden, Switzerland, Roumania, Holland, Canada, South Africa, Mexico, Japan, Brazil and New South Wales. This increase would require 720,000 trains, containing 18,000,000 cars; this is equivalent to a train 136,363 miles in length.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

AERONAUTICS.

109,598. The Sopwith Aviation Company, Limited, and T. Sopwith, both of Kingston-on-Thames, Surrey. Aircraft. (4 *Figs.*) November 1, 1916.—This invention relates to the screens provided for the face of the pilot, observer or gunner upon aeroplanes. A is the frame of the wind screen; it is of D-shape, having the straight portion A^1 on its lower side (see Fig. 2). The frame is provided with stiffening cross-bars. The horizontal bar C is connected to the member A^1 by the

Fig. 1.

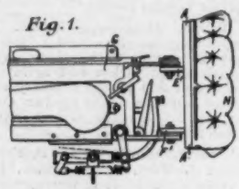
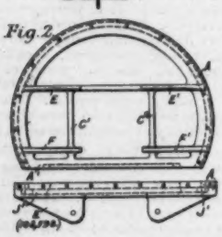


Fig. 2.



vertical bars C^1, C^2, and has integrally formed with it the two upper securing lugs E, E^1; these, together with two similar lower lugs F, F^1, serve to carry the wind screen and secure it to the gun G. The rim of the frame A is provided with holes in which is secured the thread employed for securing the covering H of leather which extends round the rim of the frame, and is packed or padded. The glass, which is preferably of the kind known as triplex, is secured in the recess J^1 of the frame, and is held in position by a metallic strip. (*Sealed.*)

ELECTRICAL APPARATUS.

109,277. L. Murphy, Slough, Buckinghamshire, and Arthur Lyon and Wrench, Limited, Westminster, London. Field Magnets. (2 *Figs.*) July 29, 1916.—This invention relates to the field magnets of dynamos and motors. According to the present invention, the applicants provide a magnet having its yoke and poles built up of laminations, the magnet being of the form wherein the field coils span practically the whole of the polar pitch, the polar portions of the magnet having extensions outward from the two sides of the main portion of the pole, forming substantially parallel sides of the interpolar space, adjacent poles having their adjacent extensions connected by short yoke portions, and the main polar portion being hollow and having a narrow passage to the pole face. The shaded portions of Fig. 1 represent two similar asymmetrical units, four

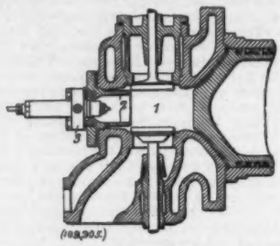
Fig. 1.

Fig. 2.

of such units forming a complete layer. The succeeding layer is formed of four precisely similar units inverted or reversed, and the position of the units in the succeeding layer is indicated by the dotted lines. Exactly the same contour is represented in Fig. 2, but in this case each layer is formed of a single lamination, and there are accordingly no imbricated joints. In each case the field coil 1 spans practically the whole polar pitch, and the polar portion 2 of the magnet being hollow a passage 3 is in this manner provided which extends through the whole length of the magnet. Extensions 4 are connected by yoke portions 5, and it will be noted that the length of these yoke portions is limited by the fact that the sides of the interpolar space are parallel. Narrow slots 6 connect the passage 3 to the pole-face. (*Accepted September* 19, 1917.)

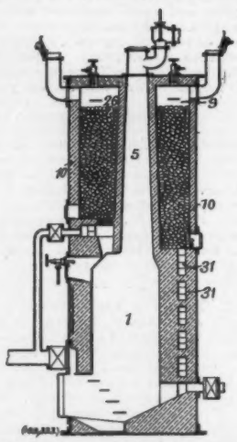
GAS ENGINES, PRODUCERS, HOLDERS, &c.

109,305. Tangyes, Limited, Birmingham, Warwickshire, and J. Robson, Handsworth, Staffordshire. Internal-Combustion Engines. (3 *Figs.*) September 7, 1916.—This invention relates to the type of engines employing heavy liquid fuel, which alone is injected by means of a pump, through a sprayer, into a body of compressed air contained in the combustion chamber of the engine. According to this invention, the device 3 which sprays the liquid fuel projects some considerable distance into the combustion chamber 1, so that its body part is exposed to the heat thereof and is surrounded by a sheath or hollow cover 2, which also projects into, and has one end open to,



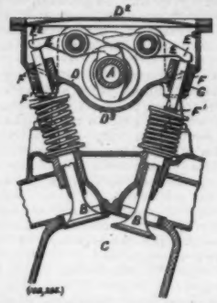
the interior of the combustion chamber, and is so arranged that its internal surface, and preferably also some part of its external surface, will be subjected to the heat due to the combustion of the charges in the combustion chamber. To increase the heating surface the said sheath or hollow cover may have ribs upon its interior or its exterior, or upon both. The said spraying device and sheath or hollow cover are arranged so that they can be readily removed and replaced. (*Accepted September* 19, 1917.)

109,323. C. B. Tully and O. E. Yeo, Westminster. Gas Producers. (3 *Figs.*) September 26, 1916.—A gas producer, according to the invention, comprises a lower gas generating chamber 1, and in communication therewith an upper fuel-supply chamber 5 made of smaller cross-sectional area, and having relatively thin walls, a steam generating chamber 9 containing refractory material, arranged in the upper part of the producer between its outer wall 10 and the fuel-supply chamber 5 and, in communication therewith, a lower or steam superheating chamber 31, also containing refractory material, arranged in the producer structure between its outer wall and the gas-generating chamber 1, and communicating at its lower end with the lower portion of the gas-generating chamber. When it is desired to manufacture gas enriched by other gas produced by the cracking of light hydrocarbon oil and the superheating of the resulting gas, the gas producer may also be provided in a position corresponding with that of the steam-generating chamber 9 with an oil-cracking or superheating chamber 26 charged with



refractory material and in communication at its lower end with the upper part of the gas-generating chamber 1, and provided with a valve-controlled inlet for admitting air to the gas produced during the blowing stage and entering the cracking and superheating chamber so as to burn it and heat the latter chamber to a high temperature. At its upper end the chamber is provided with means for admitting liquid hydrocarbon thereto and with a valve-controlled gas-outlet pipe. The arrangement is such that during the blowing stage, gas produced by passage of air more or less horizontally only through a small depth of the fuel in the bottom of the gas-generating chamber, and composed mainly of carbon dioxide and nitrogen, will pass upward through the steam superheating chamber or passage and steam-generating chamber, and that gas produced by air passing either simultaneously or subsequently upwardly through the mass of incandescent fuel, and composed mainly of carbon monoxide and nitrogen, will pass through the oil-cracking and superheating chamber and be burnt therein. (*Accepted September* 19, 1917.)

109,285. Sunbeam Motor Car Company, Limited, and L. Coatalen, Wolverhampton. Internal-Combustion Engines. (1 *Fig.*) September 1, 1916.—This invention relates to valve-operating mechanism. The present invention comprises the combination of a casing, tappets engaging valve stems passing through the casing at an angle to each other, cams between the tappets and rockers each engaging one end of the tappet, the other end of each rocker engaging one of the cams. The camshaft is shown at A, located between the valves B at the top of the cylinder C. According to this invention, a casing D, with two rockers E pivoted thereto, is employed, one at each side, and these rockers are wholly enclosed in the casing and the outer end E_2 of each rocker actuates its valve B indirectly through the medium of a short tappet rod F guided in a bush G of the casing, and having preferably a collar F_1 machined on the tappet rod. The connection between the interior and the outside of this casing is therefore through this tappet rod, and leakage can very easily be prevented by causing the bush G to project above the bottom D_2 of the casing, and by drawing off the oil therefrom at a low level, or by any other well-known means. There is no relative movement between the foot of the tappet rod and the adjacent end of the valve stem, so that there is no sliding action or friction or side thrust on the valve. Further, these tappet rods F, which may be plain cylindrical members of hardened steel, can easily be removed and changed for other of different lengths, so that the clearance or backlash in the operating mechanism can be easily taken up or adjusted. The casing D may or may not be integral with the cylinder casing



as desired, and preferably a cover plate D_2 is provided. Thus the valve can be of the same material throughout, without any hardened end to the stem, which can be of small diameter, and therefore lighter than usual. (*Accepted September* 19, 1917.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

109,395. A. Herbert, Whitchurch, Hampshire, and A. H. Lloyd, Earlsdon, Coventry, Warwickshire. Screw-cutting Taps. (5 *Figs.*) March 3, 1917.—This invention relates to screw-cutting taps, for the purpose of securing a free-cutting and self-guiding tap, so as to produce threads accurate in pitch. According to this invention, the peripheral portion of each land on the tap has greater curvature than that of the hole to be tapped, and the entering end of the leading edge forms a cutting edge, while the rear portion of the land engages the wall of the whole on a line intermediate the leading and trailing edges so as to function as a guide. The peripheral portion of each land A has a greater curvature—that is to say, it is more

Fig. 1.

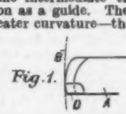


Fig. 2.

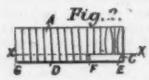
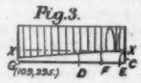


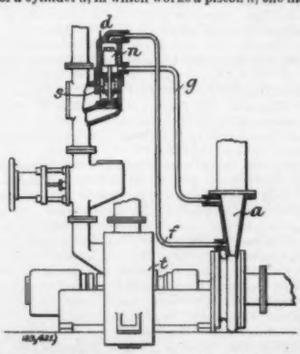
Fig. 3.



acutely curved—than the wall B of the hole to be tapped (Fig. 1). The entering end C of the leading edge D has a cutting edge extending from E to F, and the remainder of the leading edge F to G is not in contact with the wall of the hole. The line X—X (Figs. 2 and 3) indicates the line of contact between the land and the said wall, and those threads on the land which lie between F and G operate only to guide the tap. In Fig. 2 the leading edge of the land is cut back to the line X—X from E to F to form a cutting edge. In Fig. 3 the leading edge is cut back at the entering end in a line tapering with the rear end. In both Figs. 2 and 3 the line of contact X—X, between the land and the wall of the hole is parallel to the axis of the hole. (*Accepted September* 19, 1917.)

PUMPS.

109,421. G. and J. Weir, Limited, and J. G. Weir, Cathcart, Glasgow, Lanarkshire. Rotary Pumps. (3 *Figs.*) May 23, 1917.—This invention consists in a control device or governor for pumps of the centrifugal or rotary pistonless type. According to the present invention, a diverging pipe or nozzle *a* is provided at the discharge of the pump; and pipes *f*, *g* are led from two points in this pipe or nozzle respectively to the two ends of a cylinder *d*, in which works a piston *n*, the movement



of which is arranged to control the supply of actuating fluid to the motor *t* which drives the pump. A spring *s* is also arranged to act on this piston, the arrangement being such that, when the output of the pump exceeds the predetermined maximum, the difference of pressure at the two points in the diverging nozzle (from which the pipes *f*, *g* to the cylinder are led) is sufficient to overcome the force of the spring and to actuate the piston so as to reduce or cut off the supply of actuating fluid to the motor *t*. (*Accepted September* 19, 1917.)

ITALIAN BUILT SUBMARINES FOR SPAIN.—The Italian journals, says the *Revista Minera, Metalúrgica y de Ingeniería*, Madrid, show pride, and rightly so, at the fact that their country is able to supply submarines to foreign countries, and especially that it has been in a position to deliver three such craft to Spain notwithstanding the war. The Italian journals give a description of the boats, adds the *Revista*, from which it is seen that Messrs. Ercole Marelli and Co., Milan, have built the propelling machinery, electrical equipment, fans, pumps, &c., for the three units in question.